UNDERSTANDING THE RELATIONSHIP OF FEDERAL FINANCIAL SUPPORT TO THE BACCALAUREATE STEM DEGREE PRODUCTION IN U.S. COLLEGES AND UNIVERSITIES

BY

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ABSTRACT

The purpose of this study was to examine STEM baccalaureate degree production in relationship to the receipt of National Science Foundation (NSF) undergraduate education awards by the included postsecondary institutions. Data from NSF Award Abstracts and Integrated Postsecondary Education Data System (IPEDS) from 2003 to 2012 were utilized to determine how receipt of NSF funding affects STEM baccalaureate degree production (total number and proportion of all baccalaureate degrees) when holding relevant independent variables constant. In addition to total STEM degree production and production rate, STEM degree awards for women and underrepresented minority students (URMs) were also analyzed.

Findings revealed that, in most models, NSF funding was not a significant factor in the production outcomes. However, public institutions with NSF awards for URMs did produce a greater average number of STEM baccalaureate degrees by URM students. In addition, private institutions with NSF awards for STEM education produced a greater average number of STEM baccalaureate degrees in total. This study's findings suggest that the presence of NSF funding could have an impact on STEM degree production for some student populations, in some institutions, but may not for others. The varied outcomes may inform institutions and policy makers, when reflecting on the stated goal of the federal government, to increase STEM baccalaureate degree production and the impact of federal funding for such endeavors. Additional research focused on NSF funding amounts and explicit outcomes of funded projects may prove helpful to further develop policy implications and create more directive outcomes for STEM funding by NSF.

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CHAPTER I: INTRODUCTION

The fields of science, technology, engineering, and mathematics (STEM) in postsecondary education are at the forefront of education research and policy development as reports point to the need for an increasingly prepared STEM-based workforce nationally and a desire to maintain global competitiveness for related resources. Enrolling, retaining, and graduating more students in STEM fields is not only a focus of individual institutions, but also extends to the larger workforce (Center on Education and the Workforce, 2010) and the national education agenda (President's Council of Advisors on Science and Technology, 2012). A number of sources point to the need for more college-prepared STEM employees for the future workforce, indicating a subsequent need to add to the STEM education pipeline (Center on Education and the Workforce, 2010; President's Council of Advisors on Science and Technology, 2012; National Science Board, 2012; National Science Board, 2014; Rothwell, 2014; U.S. Department of Labor, 2007).

One method of addressing the federal government's role in producing the STEM-educated population necessary for national endeavors, is the provision of federal funding for STEM education through National Science Foundation (NSF) grants and awards targeted to U.S. college and university programs. While the NSF has been focused on STEM education for over 60 years, a more directed focus on education innovation and programs for improving and increasing STEM education in the U.S. has been funneled through the NSF Directorate for Education and Human Resources (EHR) since 1990 (NSF, 2014b). In fiscal year 2014, 12% ($845 million) of NSF appropriations were dedicated to EHR with a majority of the funding focused on a variety of grant awards applied to education and career efforts enhancing STEM knowledge and performance in U.S. colleges and universities (NSF, 2014a). Grant awards in

EHR are targeted to develop and support programs that build diverse, competitive, and globally engaged STEM participants. The purpose of this study is to determine if targeted federal grant funding in the form of National Science Foundation (NSF) awards directed toward undergraduate STEM education affects yearly STEM baccalaureate degree production within the institution, between the years 2003 and 2012, when holding relevant institutional factors constant. NSF funding includes grants awarded to institutions for directed initiatives in STEM undergraduate education in general, for women, and for underrepresented minorities (URMs) with the goal of increasing accessibility to STEM disciplines, promoting persistence, and ultimately increasing completion of STEM baccalaureate degrees (NSF, 2015).

In order to fully understand federal grant funding as the primary independent variable of interest, institutional characteristics focused on selectivity and type, labor resources defined by student-to-faculty ratio, institutional capital focused on institutional size and select student demographic proportions are included. Additionally, financial capital related to institutional expenditures per FTE were included to determine the relationship of NSF funding when controlling for other influential variables. Applying these inputs at the institution level allows for an increased understanding of how the institution, with the aid of targeted federal funding, produces more and more diverse STEM baccalaureate awardees over a ten year period (2003-2012). Specifically, the study explores the relationship of targeted federal funding for annual STEM baccalaureate degree production within the institution, in general, and for underrepresented groups – women and URMs. For the purpose of this study, women in STEM included all women regardless of their racial/ethnic backgrounds. URMs include those identifying as black/African Americans, Hispanic/Latino, and American Indian/Alaska Native, regardless of their gender. With this definition, it should be noted that there can be some overlap in populations for underrepresented groups between women and URMs for those identifying as URM women. This approach allows for examination of federal funding as a factor in promoting STEM baccalaureate programs and diversity to determine if NSF awards explain production patterns over a ten year period above and beyond other key institutional inputs.

As the U.S. Federal government increases the structure and accountability measures for higher education funding in science and engineering, evidence of meeting outlined goals and a return on investment for the infusion of STEM-related funds will be required of recipient institutions (Ashby, 2006; Gonzalez & Kuenzi, 2012; Scott, 2012). A report for the Government Accountability Office recommends greater coordination of federally funded programs for STEM and a need for more clearly stated outcome data from funding agencies to determine the effects of their support (Scott, 2012). In addition, Scott notes in this report that other agencies such as the President's Council on Science and Technology and the Academic Competitive Council were working on early stages of these projects including identification of STEM education programs, their goals, and the accountability and feedback systems in place. As these accountability requirements trickle-down to the funding recipients, institutions will be required to show how targeted federal funding meets federal goals for science and engineering. Approaches for increasing STEM-related goals include, but are not limited to, increasing math and science comprehension in K-12 education, recruiting and retaining more STEM majors at the undergraduate level, and filling workforce gaps with retraining for skilled STEM positions.

The demand for highly skilled and academically trained employees in the STEM fields has increased with a proposed 2 million STEM positions open at the Bachelor's or higher level in 2018 (Center on Education and the Workforce, 2010). However, the United States continues to produce fewer undergraduate STEM degrees than are awarded in other countries ((National

Science Board, 2016). Specifically, in the US, only 32.5% of baccalaureate degrees are awarded in STEM as compared to Japan (57.2%) and China (49.4%) (National Science Board, 2016). The need for such a great increase in the number of highly trained STEM employees, married with the stagnant growth of the STEM fields in the U.S., suggests a critical impasse that must be addressed, rectified, and assessed. The call has gone out to a variety of stakeholders, from federal and state policy makers to employers to institutions of higher education, to actively increase prepared individuals for STEM fields (American Institutes for Research, 2013; Ashby, 2006; Center on Education and the Workforce, 2010; National Science Board, 2010; National Science Board 2012; President's Council of Advisors on Science and Technology, 2012; Scott, 2012). This increased STEM degree production is key for the STEM workforce in the U.S., particularly for those positions requiring highly skilled employees possessing a baccalaureate degree or greater.

While a variety of initiatives focus on K-12 STEM education programs supported as strategies for increasing STEM baccalaureate degree production (i.e., targeted high school recruitment for postsecondary STEM, K-12 curricular changes, and increased teacher training), the general consensus is that retention of postsecondary students currently in the pipeline is one of the most efficient strategies for increasing STEM baccalaureate degree holders (Ashby, 2006; Kuenzi, 2008; President's Council of Advisors on Science and Technology, 2012). Obviously, the retention of students in the STEM pipeline, at many different points in the process, is an efficient approach for increasing production of baccalaureate STEM degrees. Examination of the effectiveness of targeted STEM funding at the university level allows for a deeper understanding of the impact of NSF funding on production when defined as the total number of degrees produced per year by an institution, or as a proportion of baccalaureate STEM degrees produced relative to a larger comparative group.

In addition to strategies related to providing more students in all fields through programs targeted at maintaining first-time college students originally entering STEM programs, a report submitted by the President's Council of Advisors on Science and Technology (2012) suggests an opportunity to increase production of STEM degree holders overall by focusing on underrepresented groups (i.e. women, traditionally underrepresented ethnic minorities) within the STEM fields. These underrepresented groups provide avenues for producing new sources of STEM baccalaureate degree production through recruiting within the current non-STEM population and targeting entering students who may not have initially considered STEM fields. Thus, retention strategies of STEM-engaged students at all points in the STEM pipeline and production of new STEM interests in current students (entering the STEM pipeline later in their academic career), can allow for increased total production.

While the specific means of increasing STEM baccalaureate degree production is not a current focus of this study, it is important to understand that the production of STEM degrees is affected (or can be affected) by a multitude of avenues into the STEM academic fields. Entry to STEM includes retention of students within the STEM pipeline, recruitment of students into STEM after entering postsecondary education, and recruitment of students underrepresented in the STEM fields. Despite women and underrepresented ethnic minorities (URMs) accounting for 70% of current higher education enrollment, these groups make up only 45% of undergraduate STEM degree holders suggesting a gap between enrolled students available to earn degrees in STEM fields and the awarding of STEM baccalaureate degrees to these important demographics (President's Council of Advisors on Science and Technology, 2012). In contrast to the doctoral level—where significant portions of doctoral degrees are awarded to international students, most of baccalaureate degrees awarded in the US (96%) are earned by US students. In particular, only 4% of STEM baccalaureate degrees are granted to students on temporary visas (National Science Board, 2016).

In a report focused on federal funding for STEM education for the Government Accountability Office, Ashby (2006) suggests that federal coordination of STEM education resulted in the development of programs to attract more students to STEM, including those students underrepresented in STEM fields. The President's Council of Advisors on Science and Technology (2012) reported that as of 2009 approximately 25% of STEM occupations were held by women and 8% of STEM occupations were held by URMs. Not only is there a need to produce more women and URM STEM degree holders to accurately represent these populations within the STEM workforce, but an increase in an underrepresented student population would also help fill the general employment gap for STEM fields.

The history, with regard to targeted STEM federal funding and unclear outcomes, informs the inclusion of NSF funding for STEM education as a primary variable of interest for STEM baccalaureate degree production. The funding system for STEM education does not currently include a robust system of assessment to ensure that federal funding is meeting the goals outlined, including STEM degree production. The focus of this study is to apply a method of assessing NSF funding to determine whether or not the goals of more and more diverse baccalaureate STEM degree production are being achieved by institutions receiving funding for enhanced STEM educational programs.

Research Questions

The current study is guided by six research questions. The specific outcome variables were selected to measure two types of production including overall STEM degree production or total number of STEM baccalaureate degrees and proportion of STEM degrees produced within an institution. These approaches to the dependent variables (total STEM degree production vs. proportion of STEM degree production) were included to determine how external funding affects institutional production of more degrees, and also determine if said funding affects the institutional shift in STEM production (the share of awarded degrees in STEM fields). Due to the availability of NSF funding abstracts to code the primary independent variable into three funding categories (all, women, and URM), the dependent variables relative to overall production, production for women, and production for URMs is possible with funding directed toward underrepresented populations being applied to both women and URM in the current study. The 10 year production range of 2003-2012 allows for the most complete and recent dataset for determining a pattern in baccalaureate degree production. Production is measured in two ways, by total number of STEM degrees produced and by the proportion of STEM degrees produced out of all baccalaureate degrees awarded. This approach is applied to three populations of interest including total, women, and URMs.

In an effort to understand the impact of targeted federal grant funding on undergraduate degree production by institution for STEM majors at postsecondary institutions, the following research questions were examined:

1. Does **NSF award funding** for STEM undergraduate education contribute to the **change in total yearly production of baccalaureate STEM degrees per institution** (between

2003 and 2012) in postsecondary institutions, when **controlling for institutional characteristics** including financial, labor, and institutional capital?

2. Does **NSF award funding for women** in STEM undergraduate education contribute to the **change in yearly total production of women baccalaureate STEM degrees per institution** (between 2003 and 2012) in postsecondary institutions, when **controlling for institutional characteristics** including financial, labor, and institutional capital?

3. Does **NSF award funding for URMs** in STEM undergraduate education contribute to the **change in yearly total production of URM baccalaureate STEM degrees per institution** (between 2003 and 2012) in postsecondary institutions, when **controlling for institutional characteristics** including financial, labor, and institutional capital?

4. Does **NSF award funding** for STEM undergraduate education contribute to the **change in yearly ratio of STEM baccalaureate degrees produced to all baccalaureate degrees produced per institution** (between 2003 and 2012) in postsecondary institutions, when **controlling for institutional characteristics** including financial, labor, and institutional capital?

5. Does **NSF award funding for women** in STEM undergraduate education contribute to the **change in yearly ratio of women STEM baccalaureate degrees produced to all STEM baccalaureate degrees produced per institution** (between 2003 and 2012) in postsecondary institutions, when **controlling for institutional characteristics** including financial, labor, and institutional capital?

6. Does **NSF award funding for URMs** in STEM undergraduate education contribute to the **change in yearly ratio of URM STEM baccalaureate degrees produced to all STEM baccalaureate degrees produced per institution** (between 2003 and 2012) in postsecondary institutions, when **controlling for institutional characteristics** including financial, labor, and institutional capital?

The method of analysis applied to the defined outcome variables is random effects regression modeling. Random effects modeling was selected because it allows for inclusion of time-variant and time-invariant independent variables into the model, can be applied to longitudinal panel data, and provides a measure of 'within-institution' change over the timeline (Allison, 2009). Basically, the patterns of change within an institution are more likely to be important to the outcome variable than the changes between individual institutions and the random effects model accounts for this reality. By understanding how individual institutions may change resource patterns to enhance STEM degree production, all U.S. institutions may be part of the intervention strategy and not simply those grouped by fundamental differences (such as high research vs. low research or large enrollment vs. small enrollment). The reasons for selection of the random effects regression approach are important as the literature guided this study to include both time-variant (NSF funding, institution enrollment, expenditures, STEM enrollment, average SAT scores, etc.) and time-invariant (Carnegie classification, HBCU/Women's College, etc.) variables as predictors of general baccalaureate degree production.

Additionally, the focus of the current study on the effects of external federal funding within an institution require a method of analysis that can incorporate within-subject results over a long enough time period to allow for effects to occur. The results of random effects modeling allow for findings of whether or not NSF funding affects the total number of STEM degrees produced and proportion of STEM degrees by an institution over time, after holding related production inputs constant. An additional benefit of random effects modeling is that findings related to the time-invariant variables allow for analysis of between-institution production such that differences between characteristics of institutions are also tested. Application of the random effects model to the available panel data allows for more conceptually sound policy recommendations based on within-institution effects, along with between-institution outcomes (Allison, 2009; Zhang, 2010). In summary, the outlined research questions serve to examine the effects of targeted NSF grant funding at capacity building for STEM degree production.

Conceptual Perspectives

The study is guided by two primary theories including the education production function theory (Hopkins, 1990) and the principal-agent theory, as applied to higher education (Lane & Kivisto, 2008). The application of the education production function to this study is the main driver for explaining the relationship between institutional inputs (number of students, expenditures, student-to-faculty ratio, selectivity, institution type) and the institution’s production of baccalaureate degrees in STEM, in total and for women and URMs separately. Within higher education, capital and labor equate to financial capital or revenues and expenditures, institutional capital or characteristics of the college/university and student demographics, and labor or faculty (Hopkins, 1990; Massey, 1996).

Applying these inputs at the institution level allows for an increased understanding of how the production pattern of an institution, with the aid of targeted federal funding for undergraduate education in STEM, changes by year over a ten year period of examination. The specific period of examination, ten years, allows for measurement techniques to determine how external funding infusion can change the production landscape. Utilizing lagged funding variables and allowing enough time to determine how funding may or may not affect STEM baccalaureate degree production is important to determining the within-institution impact or the way in which the pattern of independent variables within an institution affect the average change. Additionally, due to the small number of targeted grants and awards for specific populations, the ten year span allows for more opportunities for institutions to receive funding and be tested within the models. Thus, for an institution that does not regularly receive NSF funding awards, but did develop a meaningful STEM education program, the impact of that funding and programming will have a chance to affect production without being excluded in a cross-section that does not have the rich data detail.

In an effort to provide greater structure to the general concepts of the education production function, the application of the principal-agent theory is necessary to guide the inclusion of federal capital sources to preexisting institutional capital and labor inputs as the primary focus of the study. The principal (U.S. government via NSF funding in the current study) essentially has a goal or goals that need to be met and requires the environment, labor, and capital of another entity to achieve the said goal(s). The agent (postsecondary institutions in the current study) is an entity with the means to produce a desired outcome for a principal, generally with the assistance of their resources. In general, the application of the principal-agent theory to higher education suggests that a university is not acting as an efficient agent of the state when government funds (or increased input) do not result in efficient and effective outputs (Lane & Kivisto, 2008). In addition, the theory states that the relationship between the principal and agent is not necessarily aligned and, thus, the agent must be incentivized and/or systematically monitored to ensure that desired outcomes are met.

Utilization of the principal-agent theory to explain higher education outcomes builds on previous studies focused on the application of resources, particularly financial inputs, to desired outcomes by a secondary party of influence (Kivisto, 2007; Lane, 2007; Titus, 2009a). Specifically related to the current study, Titus (2009a) notes that the influence of the principal (a U.S. state government) upon the agent (institutions of higher education within that state) to produce degrees is a relevant application of the theory. The study examined the relationship between a state's policy recommendation to increase need-based aid and their expectation that institutions of higher education within the state produce more baccalaureate degrees when receiving specific forms of aid for such purposes. Within the current study, the influence of federal funding at the institution level to produce more STEM baccalaureate degrees and a greater diversity of STEM awards as defined by relative programs suggests that the principal-agent effect of the federal-institution relationship is directly linked to the output produced through the application of the education production function.

This study incorporates both theories to provide a supported framework for the inclusion of external economic funding to existing capital and labor sources as relevant to the production of baccalaureate STEM degrees overall for underrepresented populations and to determine the relationship between federal funding sources and the production function. Greater detail on each theory and how these theories relate to the study may be found in Chapter II.

Baccalaureate Degree Production – General Production & STEM Production

The current body of research focused on baccalaureate degree production provides a framework informing the current study. Review of available literature reveals fewer studies with direct focus on the production of STEM baccalaureate degrees at the institutional level, but a foundation upon which to build is available. This lack of current research could be due to the fairly recent call for increases in this area by the government and education researchers married with the need for a long enough duration in order to determine change at an institution-level. Consideration of prior research in these areas in conjunction with the conceptual framework and focus on education production capital sources, informed the research design to most effectively answer the research questions within this study. An overview of baccalaureate degree production, both generally and for STEM degrees specifically, follows.

Baccalaureate degree production has been studied from a variety of vantage points. One of the fundamental perspectives pertinent to the current study is the effectiveness of the institution in overall degree production and relative production rates (Archibald & Feldman, 2008; Ryan, 2004; Scott, Bailey & Kienzl, 2006; Webber & Ehrenberg, 2010; Zhang, 2009). These findings suggest that inclusion of key institutional capital variables to production studies is essential in an effort to address and hold constant those inputs found to have predictive power in the education production function of baccalaureate degree production. Institutional inputs including enrollment in an institution focused on a specific community, such as the Historically Black Colleges & Universities (Webber & Ehrenberg, 2010), and institutional control (Scott, Bailey, & Kienzl, 2006; Webber, & Ehrenberg, 2010) are found to have an effect on education production rates as well. These general baccalaureate degree production studies provide the foundation for exploring the education production function in terms of specialized degrees, specifically for STEM baccalaureate degrees in this study.

Existing literature on the production of baccalaureate STEM degrees at the institution level is limited. While a number of studies focus on institutional characteristics within the academic persistence and success of individual students in STEM (Anderson & Kim, 2006; Chen, 2013; Chen, 2009; Crisp, et al., 2009; Huang, G et al., 2000; Riegle-Crumb & King, 2010; Snyder & Dillow, 2013; Wang, 2013; Whalen & Shelley, 2010), only a few focus on the overall institutional production function for baccalaureate degrees in the STEM fields (Hurtado, Eagan, & Hughes, 2012; Sonnert, Fox, & Adkins, 2007; Zhang, 2011). Research findings from studies focused on underrepresented demographic groups in STEM education also suggest different outcomes for these groups including stable growth of URM STEM degree production with increases in overall degree production and an increase in the proportion of STEM degrees awarded to women over time (Hurtado, Eagan, & Hughes, 2012; Sonnert, Fox, & Adkins, 2007). Due to these findings, STEM production for women and URMs separately is considered in conjunction with total STEM baccalaureate degree production.

Finally, baccalaureate degree production utilizing financial capital from an external source to produce specific, mutually desired output, is relevant to the research study and informs the inclusion of NSF funding as a potential driver of increased STEM baccalaureate degree production. In particular, two studies by Titus (2009a, 2009b) focused on baccalaureate degree production suggest that financial infusion from related, external parties resulted in an increase in the total number of baccalaureate degrees produced per institution and subsequently at the overall state level as well. The principal approach in these studies included funding to state institutions of higher education for need-based aid to students by the state (acting as the principal). These findings help ground the inclusion of NSF funding per the principal-agent theory to serve as the key focus of the current study. Despite a number of notable studies on baccalaureate degree production in higher education in general, there is a need for research exploring postsecondary institutions as producers of STEM degrees for the U.S. workforce demand.

Significance of Study

In a speech to the National Academy of Sciences addressing the need for highly prepared STEM students and employees, the President of the United States suggested the following,

> American students will move from the middle to the top of the pack in science and math over the next decade. For we know that the nation that out-educates us today—will out-compete us tomorrow (Obama, 2009 para. 58).

This statement encompasses the fundamental significance of the study, production of more and more highly skilled STEM graduates for the workforce needs of the future. Building upon the call of the President, a variety of more recent reports present details regarding specific needs within the development of the STEM pipeline. These reports outline increased enrollment overall and of underrepresented groups in STEM, creating curriculum to help support the needs of STEM students, developing federal and state policy to help drive production of STEM degrees, and engaging stakeholders (such as employers) to participate in the process (American Institutes for Research, 2013; Center on Education and the Workforce, 2010; President's Council of Advisors on Science and Technology, 2012). A national call for increased STEM degree production for education and industry, coupled with the predictions of a production shortfall, is the overarching driver of this course of research with a goal to inform federal policy development efforts for driving STEM degree production.

The body of research dedicated to baccalaureate degree production provides a history of empirical evidence of predictors of degree production at both the general level and (to a lesser degree) STEM discipline level, but does not directly address the relationship of federal funding for STEM education. The goal of this study is to apply the findings from the current body of literature to a framework of education production within a principal-agent relationship to determine if NSF funding targeted for undergraduate STEM programs is being utilized within institutions to produce more STEM baccalaureate degrees. The findings inform whether or not the economic transaction of federal funding via NSF awards for STEM education produce one of the government's stated goals for STEM education, increased baccalaureate degree production. More simply, the goal is to determine if institutions act as effective agents for the U.S. government (or principal) when receiving resources for STEM undergraduate education.

Organization of the Dissertation

Chapter I of the dissertation outlined key issues in baccalaureate degree production and workforce demand, as well as STEM degree production and external funding sources, to illuminate the research problem. In addition, the supporting body of research, the conceptual framework, and data sources guiding the research design and methodology were presented. Finally, significance for the study as related to relevant research and potential policy implications was discussed.

Chapter II will present a literature review supporting the study in three parts. Part 1 focuses on the relevant concepts within the research questions, baccalaureate degree production in general and for STEM disciplines and the application of external funding to degree production. Part 2 will more thoroughly detail the conceptual framework for the study, including Hopkins (1990) education production function theory and the application of the principal-agent theory to higher education (Lane & Kivisto, 2008). In Part 3, limitations of current research are further discussed and highlighted by empirical findings.

Chapter III will present the methodology for study and detail on data sources. The chapter will include a discussion of the reason for data selection, applicability of statistical methodology, and included variables.

Chapter IV will include the results of the application of methodology defined in Chapter III. General patterns of outcome variables for each research question, by institutional control, are examined. In addition, the results of the model applied to determine significant factors for longitudinal growth or decline in total STEM degree production and production rates are presented for STEM degree production in total, for women, and for URMs. The chapter will conclude with a summary of significant independent variables by measured outcomes.

Chapter V will focus on a discussion of the model results from Chapter IV, applied to the study's conceptual framework, with particular emphasis placed on NSF funding. Policy implications and future research opportunities are posed as part of the chapter. The chapter will conclude with a summary of the study.

CHAPTER II: CONCEPTUAL FRAMEWORK & RELATED LITERATURE

Chapter II provides an overview of the guiding conceptual framework and previous findings informing the study design and approach. The study is guided by two primary theories including the education production function theory (Hopkins, 1990) and the principal-agent theory as applied to higher education (Lane & Kivisto, 2008). The pairing of these theories provides a theoretical framework for including external NSF STEM funding into the education production model such that institutions become agents for the federal goals of increased STEM degree production through economic transactions. In addition, a review of previous research findings related to degree production, institutional capital and labor, and financial capital are provided to support the inclusion of specific variables in the model.

The chapter is organized in a manner that focuses first on the background of STEM baccalaureate degree production needs and the intersection with federal funding for STEM undergraduate education. This is followed by a discussion of education production function theory and supported research, then the principal-agent theory and supporting research in a comprehensive literature review. Additionally, limitations of the current research are introduced and discussed.

Perspectives on STEM Degree Production & External Funding

The utilization of both the education production function theory and principal-agent theory is driven by national goals and approaches for increasing undergraduate STEM education in the U.S. For example, among the overarching goals of the Government Accountability Office the production of more and more diverse STEM baccalaureate recipients for employment and graduate study in needed STEM fields are outcomes that can be readily examined utilizing nationally provided data sources (President's Council of Education and the Workforce, 2010). The utilization of panel data in the current study allows for determination of production patterns by examining yearly outcomes over a ten year time period. By increasing knowledge on how the presence of directed NSF funding affects the production of critically important STEM degrees, policy implications at the institution and federal levels may be developed to better guide the allocation of funding resources and build viable systems of accountability to ensure national goals are met. If NSF funding is a factor for STEM baccalaureate degree production at the institution level, administrators within those institutions can strategically apply institutional resources to gain STEM education grants and awards and enhance programs and production of STEM degrees. At the federal level, evidence of funding not producing the desired results of an increased skilled workforce for STEM may suggest a retooling for funding awards in STEM and more directive requirements for performance and assessment upon receipt of these awards.

More specifically, the need for a highly skilled workforce and academic researchers suggests bachelor's-level or greater degree holders in the fields of science, technology, engineering, and mathematics will continue to be highly necessary for maintaining and increasing global position in STEM fields (National Science Board, 2014). In fact, a report from the Center on Education and the Workforce (2010) suggests that occupations within the STEM fields are part of a group that, by 2018, will show a favorable employment trend to those with a related baccalaureate degree. Supporting this finding, the President's Council of Advisors on Science and Technology (2012) report a required one million more undergraduate degrees in science, technology, engineering and mathematics than the current production rate, indicating a need to increase undergraduate STEM degree holders by approximately 34% from their existing standing. A study examining the gap between a prepared STEM workforce and market demand suggest that STEM positions take longer to fill than other fields due to the lack of qualified applicants available and advanced STEM skills frequently obtained through higher education extend the length of time positions are openly advertised (Rothwell, 2014). While the estimates for prepared STEM degree holders fall woefully short of workforce demand, institutional efforts to build the supply are not currently aligned with this deficit (American Institutes for Research, 2012).

The call for increased production of publically desired degree fields by the government includes the provision of resources, specifically funding for STEM education programs, to achieve this goal. Kuenzi (2008) specifically noted that the federal role in promoting STEM education and preparing an educated workforce to fill current and future gaps is providing funding toward STEM education efforts. While this role is undisputed by the U.S. Department of Education (2007) in a report of the Academic Competitive Council, their impact study on the effectiveness of STEM targeted funding programs to a variety of education institutions revealed unsuccessful and unclear outcomes. More specifically for STEM funding at the undergraduate level, a focus on increasing STEM enrollment and completion at institutions as a result of funding was examined to determine effectiveness of STEM funding at the undergraduate postsecondary level. Their report revealed that the programs examined did not trend toward production of STEM-related goals and that additional research was needed to determine effectiveness of programs and provide more direct connections between funding and outcomes. Among their recommendations is the expansion of the federal role to not only provide funding, but also accountability structures to more publicly report use of funding to meet national goals.

The application of the education production function to this study is the main driver for explaining the relationship between institutional inputs or capital and the production of baccalaureate degrees in STEM, particularly for women and URMs. In very basic terms, Hopkins (1990) describes this economic construct as the means by which inputs (labor and capital, precisely) are transformed to outputs. In an effort to provide greater structure to the general concepts of the education production function, the application of the principal-agent theory is necessary to guide the introduction of federal capital sources to preexisting institutional capital and labor inputs. In general, the application of the principal-agent theory to higher education suggests that a university is not acting as a meaningful agent of the state when increases in inputs, such as government funds, do not result in efficient and desired outputs such as increased degree production (Lane & Kivisto, 2008).

Education Production Function

Hopkins (1990) defines the education production function, in general terms, as the means by which an institution creates outputs from a set of inputs. More specifically, these inputs are defined as the "capital" and "labor" employed in the production process for a particular output. Massy (1996) describes institutional inputs and outputs in higher education as "very numerous, some are highly intangible, and many of their values accrue over time" (p. 57). In addition, productivity is a difficult concept to define due to issues of quality and intangibility of both inputs and outputs. However, Baumol, Blackman, and Wolff (1989) propose that 'gross productivity' is a measurement of output production that can be key to understanding a variety of behaviors including the production of needed manpower for future endeavors. While the language does not precisely mirror that of higher education, manpower production could reasonably be translated as degree production for the purposes of this study. Specifically, Baumol et al. (1989) describe the concept of gross productivity as the amount of output produced by relative input, without regard for changes in the quality of the output.

Hopkins (1990) and Massy (1996) do note a number of tangible inputs related to institutional resources (capital) and faculty (labor), as well as quantifiable outputs. One such output supported within the description of the education production function is degree production, the focus of the study. In an effort to more clearly define the application of education production function to the study of baccalaureate degree production, and more specifically the production of STEM degrees, related research is discussed. Previous findings guiding the development of the current study are presented as they relate to the baccalaureate and STEM degree production outcomes and the role of institutional capital and labor resources as input functions for baccalaureate and STEM degree production.

Degree Production: Baccalaureate & STEM Degree Production Literature Review

The education production function theory has been applied widely to higher education, specifically the production of degrees. In this section, previous research addressing baccalaureate degree production through the application of the education production function is synthesized and presented. General findings on baccalaureate degree production and more specific STEM baccalaureate degree production are discussed. Due to the nature of baccalaureate degree production being measured as a graduation rate most frequently, the majority of the supporting literature relates to production as a defined graduation rate. In addition, related findings focused on degree production for underrepresented STEM groups (defined as women and URMs for this study) are noted. Following a review of the literature related to the overall production function, institutional capital and labor resources are discussed in the context of prior empirical study.

Baccalaureate degree production has been studied from a variety of vantage points. One of the fundamental perspectives pertinent to the current study is the ability of the institution to utilize available resources as inputs in overall degree production and relative production rates to effectively produce as many as possible with the resources afforded at the time (Archibald & Feldman, 2008; Ryan, 2004; Scott, Bailey & Kienzl, 2006; Webber & Ehrenberg, 2010; Zhang, 2009). These studies approach the production of baccalaureate degrees by including related capital (financial and institutional capital) and labor inputs as the drivers of undergraduate degree output. Although the focus of these studies is often on the effects of specific expenditures and revenue sources (financial capital) in the production of baccalaureate degrees, attention is also directed to student inputs (institutional capital) and faculty (labor resources) as these inputs are often predictors of greater degree production when compared across institutions.

One way of measuring production is by capturing the graduation rate of a selected group of undergraduate students, generally incoming freshman. For example, Ryan (2004) finds that increased expenditures in areas such as instructional and academic support per student FTE result in higher graduation rates for defined cohorts in Baccalaureate I and II institutions. In addition, Ryan's study suggests that institution size is related to degree production with larger institution size having a positive effect on the degree production rate. While graduation rate studies have analyzed effects of inputs on graduation rates for defined populations, the possibility of others entering the STEM pipeline at different places (internal program transfers, institution transfers) to create STEM baccalaureate awardees cannot be measured. The current study is designed to understand total STEM degree production and not just that of a specific group at one point in the baccalaureate degree production cycle.

Webber and Ehrenberg (2010) employed panel data to analyze the production function, reported that increases in student services expenditures, among others, result in higher graduation rates, particularly for those institutions with more Pell recipients and lower SAT scores. In addition, they found that institutions with higher SAT scores, more Asian American students, and Historically Black Universities and Colleges had higher 6-year graduation rates for their baccalaureate cohorts, while institutions with a larger proportion of male, African American, and American Indian students had lower graduation rates. Their findings were distributed across more institutions representing a variety of Carnegie classifications and expanding the generalizability of the findings from Ryan's study. Scott, Bailey, and Kienzl (2006) also focused on the financial capital of institutions by looking at the differences in baccalaureate degree production between private and public institutions. Interestingly, they found that a large portion of variance between public and private institution graduation rates is explained by student characteristics, not resource allocation. Thus, institutional capital inputs such as SAT scores, percent of undergraduates enrolled full-time, percent of students living on campus, etc. explain increased graduation rates for public institutions.

Zhang (2009) applies state appropriations (revenue vs. expenditure) to degree production rates to determine that an increase in state appropriations of 10% per student FTE results in a 0.64% increase in the graduation rate. Zhang's study suggests that external funding can increase the graduation rate for an institution and provide support for examining whether an infusion of economic resources, targeted toward a specific educational purpose, can increase other measures of production such as total STEM degree awards or proportion of degree production by STEM fields for an institution. Additionally, findings from analysis of the institutional variables included in the model as control variables reveal that institutions with higher SAT scores, a lower population of URMs, and a higher population of women have higher graduation rates. Archibald and Feldman (2008) noted the importance of labor input via full-time faculty in their study of statistical approaches to degree production output. They found that those institutions with a greater proportion of full-time faculty reported higher graduation rates.

These general baccalaureate degree production studies provide the foundation for exploring the education production function in terms of specialized degree production, specifically for STEM baccalaureate degrees in this study. In particular, the findings suggest the inclusion of variables representing institutional capital, financial capital, and labor resources are necessary to account for other inputs affecting degree production and place total production and production as a proportion of a specified group in the context of the education production function. Research focused on the production of STEM degrees is discussed briefly before looking more closely at the production of baccalaureate degrees in STEM for underrepresented demographic groups, women and URMs.

Upon examination, there appears to be less existing literature on the production of baccalaureate STEM degrees at the institution level. While a number of studies focus on institutional characteristics within the academic persistence and success of individual students in STEM (Anderson & Kim, 2006; Chen, 2009; Chen, 2013; Crisp, et al., 2009; Huang, G et al., 2000; Riegle-Crumb & King, 2010; Snyder & Dillow, 2013; Wang, 2013; Whalen & Shelley, 2010), only a few focus on the overall institutional production function for baccalaureate degrees in the STEM fields (Chang et al., 2008; Hurtado, Eagan, & Hughes, 2012; Sonnert, Fox, & Adkins, 2007; Zhang, 2011). The primary focus of the studies looking directly at undergraduate STEM degree production vary in focus including institutional selectivity (Chang et al., 2008), financial support structures (Zhang, 2011), and underrepresented demographic groups within STEM fields (Hurtado, Eagan, & Hughes, 2012; Sonnert, Fox, & Adkins, 2007).

Despite the student-level data analysis applied to the study, Chang et al. (2008) included institutional drivers of persistence for URMs in biomedical and behavioral science majors. They found support for greater institutional selectivity as a vehicle for increased degree persistence and attainment, particularly among URM students. Again, while graduation rate is not the focus of the current study, the application of institutional selectivity (avg. SAT score) did affect the graduation rate of students and, thus, the production levels between institutions. A change in the selectivity within an institution over time, thus, could be responsible for a greater production of baccalaureate degrees in general and should be included in the model to account for these changes. This finding was supported in part by Hurtado, Eagan, and Hughes (2012); however, their findings, looking at degree production for women undergraduate students in both STEM and non-STEM fields, suggested that more selective institutions (based on SAT scores) had greater degree completion rates. The findings point to a need to include an indicator of selectivity (or academic preparation as measured by SAT scores) to help control for the increased completion efficiency of more selective institutions.

Zhang (2011), in a study focused on state-level financial support programs for Georgia and Florida, found that merit-aid programs did, in fact, have a positive effect on the production of STEM baccalaureate degree production for the state (5-7% increase in Georgia and 10-13% increase in Florida in total STEM degrees produced). Production increases were even greater for female STEM baccalaureate degree production (8% increase in Georgia and 14% increase in Florida in total STEM degrees produced by women), suggesting differing effects of inputs for the output of varied groups within the STEM degree production dynamic.

Research findings from studies focused specifically on underrepresented demographic groups in STEM education (women and underrepresented ethnic minorities) also suggest different outcomes for these groups. Sonnert, Fox, and Adkins (2007) found that the production (as defined by the proportion of STEM degrees awarded to women) of science and engineering baccalaureate degrees for female students increased over the course of time and that growth was greater with the presence of a larger proportion of female faculty. In addition, research suggests that institutions classified as women's colleges produce a larger proportion of female science-related graduates than other institution types (Wolf-Wendel, 2002), despite producing a very small proportion of total undergraduate degrees (Women's College Coalition, 2014). Hurtado, Eagan, and Hughes (2012) found institutional contexts affecting URM STEM degree production numbers including a stable growth of URM baccalaureate STEM degree completions with the relative increase in overall URM undergraduate degree production.

A clear product of the literature review for baccalaureate and STEM degree production is the need for more studies focused on total production, not just graduation rate production. This is a needed addition to the literature as the graduation rate method narrowly defines a group of measurement and does not allow for consideration of field/major changes within the institution and a growing number of transfer students from other postsecondary settings. One contribution of the current study is to add to the knowledge base of total baccalaureate degree production in STEM fields.

In the following section, application of the education production function literature to relevant institutional capital and labor resources for the current study is examined and discussed. Particular attention is paid to how financial capital, institutional capital, and labor resources at the institutional level have been applied to baccalaureate degree production in general, relevant to STEM fields, and more specifically to women and URM students in STEM.

Institutional Capital & Labor: Baccalaureate & STEM Degree Production Literature Review

Massy (1996) and Hopkins (1990) both note specific areas of capital and labor resources in the production of higher education outputs including institutional capital in the form total enrollment and proportion of enrollment of key groups (STEM, women, and URM), financial capital in the form of expenditures and revenue streams, and labor in the form of faculty effort such as student-to-faculty ratio. In an effort to employ these basic measures of postsecondary education capital and labor within the current research model for STEM baccalaureate degree production, related literature is presented. A discussion of institutional capital, financial capital, labor resources, and general institutional characteristics from the perspective of production function inputs for general and STEM-specific baccalaureate degree attainment follows.

As would be expected in research on baccalaureate degree production, numerous studies include measures of institutional capital within the input function (Archibald & Feldman, 2008; Chang et al., 2008; Hurtado, Eagan, & Hughes, 2012; Ryan, 2004; Scott, Bailey & Kienzl, 2006; Sonnert, Fox, & Adkins, 2007; Webber & Ehrenberg, 2010; Zhang, 2009). Many of these studies include overarching indicators of institutional capital that have been found to have an effect on degree production at some level whether it be the graduation rate of defined incoming cohorts or the overall total degrees awarded by an institution. Specific forms of institutional capital reported to have an effect on baccalaureate degree production include the following: proportion of enrollment by gender (Ryan, 2004; Scott, Bailey, & Kienzl, 2006; Webber & Ehrenberg, 2010; Zhang, 2009) proportion of enrollment by underrepresented minorities (Scott, Bailey, & Kienzl, 2006; Webber & Ehrenberg, 2010; Zhang, 2009), total FTE enrollment (Ryan, 2004; Scott, Bailey, & Kienzl, 2006; Zhang, 2009), and a measure of academic ability and institutional selectivity, generally in the form of SAT scores (Archibald & Feldman, 2008;

Hurtado, Eagan, & Hughes, 2012; Scott, Bailey, & Kienzl, 2006; Webber & Ehrenberg, 2010; Zhang, 2009).

Studies focusing on the production of STEM baccalaureate degrees included STEM-specific institutional capital indicators such as proportion of enrollment in STEM majors (Hurtado, Eagan, & Hughes, 2012), proportion of gender within STEM enrollments (Sonnert, Fox, & Adkins, 2007), and institutional history of graduating science and related majors (Chang et al., 2008). The importance of the aforementioned studies focused on STEM degree production is that the findings guide the current study's focus on proportions of STEM enrollments and set a precedence for the inclusion of relative STEM institutional capital indicators to provide a foundation for the inclusion of specific groups of interest within the environment of general baccalaureate degree production.

In addition to institutional capital, financial capital is often included in studies focusing on baccalaureate degree production (Ryan, 2004; Scott, Bailey, & Kienzl, 2006; Webber & Ehrenberg, 2010; Zhang, 2009; Zhang 2011). Ryan (2004) and Scott, Bailey, and Kienzl (2006) capture financial capital in the form of total student expenditures per student FTE. Scott et al. (2006) suggest that utilizing this overarching measure of expenditures is a sound strategy as this figure encompasses institutional revenue and its subsequent distribution for application to the general production function. Webber and Ehrenberg (2010) focused on specific areas of expenditures per student FTE including student services, research, and institutional as the focus of their production study.

Zhang (2009, 2011) also approached the importance of financial capital in studies looking at the power of state funding via appropriations and merit-aid (per student FTE) to predict the production function for baccalaureate degrees at public 4-year institutions and STEM baccalaureate degrees at the state level, respectively. Zhang (2009) found that a 10% increase in state appropriations per FTE student predicts just over a half-percent increase in graduation rates for incoming undergraduate cohort students. Similarly, Zhang (2011) found that two states with merit-based programs for in-state education found increased baccalaureate degree production after implementation of the funding programs. In addition, total STEM baccalaureate degrees awarded increased over a 15 year period before and after merit-aid in both public and private institutions.

Complementing capital inputs to the education production function, the input of institutional effort or "labor" resources is included in studies focused on degree production (Archibald & Feldman, 2008; Scott, Bailey, & Kienzl, 2006). Of these studies utilizing labor within the production function, two focus on the student-to-faculty ratio as the measure of input (Archibald & Feldman, 2008; Scott, Bailey, & Kienzl, 2006). Specifically, Scott, Bailey, and Kienzl (2006) note that the use of the student/faculty ratio not only represents a measure of labor input at the institution level, but also provides a meaningful measure of the availability of labor distribution to the institutional capital included in the function. The current study utilized student-to-faculty ratio as the measure of institutional labor.

The literature focused on the baccalaureate degree production function, both generally and related to STEM degree production, provides a basis by which to include institutional, labor, human, and financial capital inputs to the model. In addition to these elements, this study focuses on the effect of an external input allocated to the production output of interest, STEM baccalaureate degrees. The next sections will outline a theoretical framework for inclusion of federal STEM funding to the education production function for STEM baccalaureate degrees in postsecondary institutions. Additionally, supporting literature related to the application of this theory is presented.

Principal-Agent Theory in Higher Education

The application of the principal-agent theory in higher education theory (Lane & Kivisto, 2008) allows for the addition of "state-controlled" capital to the education production function. Specifically, the central theme of the principal-agent theory relative to higher education is the concept of the relationship's effectiveness or the ability of the agent to utilize the principal's or multiple principals' capital to meet the expectations of the principal(s). The contractual relationship between a principal and agent to have the agent produce something that will improve the position of the principal is the major concept of the overarching principal-agent model (Alchian & Demsetz, 1972; Jensen & Meckling, 1976). Lane and Kivisto (2008) discuss both economic and political applications of this model to higher education, suggesting that principal-agent relationships in higher education often serve both by having multiple principals and producing both economically-driven and public good outcomes.

Economic principal-agent theory encompasses a more direct, economic impact in the relationship between the principal (Federal government) and agent (institutions). Lane and Kivisto (2008) reference economic-related products within this concept including the cost of higher education and the productivity level of universities. Supporting the economic principal-agent theory within the purview of higher education, the political science principal-agent theory allows for a more realistic application of the model because higher education institutions tend to have a variety of principals to which they act as agents (Lane & Kivisto, 2008). In addition, the political view allows for a more clear focus on the output of public goods and allows for the influence of a principal as one among many, meaning the hierarchy is not as clearly defined and the choice to end the relationship between the principal and agent will not necessarily result in the termination of the output. The concepts of economic and political principal-agent theory are considered together for the current study as the defined output represents economically-driven productivity and politically-driven workforce and knowledge development.

Previously discussed inputs to the production function are presented in terms of institutional capital (financial, human, and institutional characteristics) and institutional labor, those resources governed most directly by the institutions. However, the introduction of capital from external sources with specific targets for allocation suggests an additional form of financial capital with a more direct purpose. An infusion of financial support, specifically for STEM-related endeavors at the institution-level, provides a means by which to measure the principal-agent theory in conjunction with education production function theory.

This study incorporated both theories to allow for a general model of STEM baccalaureate degree production utilizing the education production function with a theoretical framework for including NSF STEM funding to increase baccalaureate degree production patterns as explained by principal-agent theory. Specific research detailing related findings of principal-agent theory in higher education production follows.

Principal Financial Capital: Higher Education as Production Agent Literature Review

As has been previously discussed, empirical application of the education production function to STEM baccalaureate degree production is limited (Chang et al., 2008; Hurtado, Eagan, & Hughes, 2012; Sonnert, Fox, & Adkins, 2007; Zhang, 2011). Similarly, application of external federal funding sources to the production of STEM baccalaureates has been little studied, despite serving as a possible indicator of how the agent of higher education institutions serve the goal of the federal principal interested in research production, workforce development, and maintaining and increasing global presence in fields related to STEM.

However, principal-agent theory has been applied to higher education outcomes and policy development in higher education. A number of researchers have previously applied the principal-agent model to studies of higher education (Kivisto, 2007; Lane, 2007; Liefner, 2003; McLendon, Deaton, & Hearn, 2007; Payne & Roberts, 2004; Titus, 2009a; Titus, 2009b). These studies span a number of 'principal' definitions including primarily those at the U.S. state-level (Lane, 2007; McLendon, Deaton, & Hearn, 2007, Titus, 2009a; Titus, 2009b), but also at the U.S. federal-level (Payne & Roberts, 2004) and international-level (Kivisto, 2007; Liefner, 2003). Notable among all of these studies is the proposition that one driving force of higher education production is the principal(s) for which the institution acts. More specifically, a number of these studies discuss the financial support (among other resources) of the principal to fuel the agent's compliance with providing a greater output of the principal's desired 'product' (Kivisto, 2007; Payne & Roberts, 2004; Titus, 2009a; Titus 2009b). Basically, if an entity wants more of a product created outside of its own capability, it will provide financial support to help increase the production level with the understanding that the funding is for that select purpose.

In addition to direct reference of the principal providing financial input to the agent to reach a desired goal, more broad applications to government oversight and governing structure are suggested (Lane, 2007; Payne & Roberts, 2004). As well as the principal resources serving as a form of capital for the agent to utilize in meeting principal goals, the concept of change over time by the principal as a factor of change in agent production is also presented encompassing the idea that an ever-changing political environment will open opportunities for the principal to offer new resources to the agent (McLendon, Deaton, & Hearn, 2007). This concept closely mirrors the theoretical underpinnings of the education production function by suggesting principal inputs influence agent outputs and the opportunities provided by principals (inputs) can change to alter the production landscape for the agent.

While the principal-agent theory has been applied to a variety of studies and concepts within higher education, those findings related to the institutional production function are most directly applicable to the current study. In particular, two studies by Titus (2009a, 2009b) focused on baccalaureate degree production suggest that financial infusion by the principal (in both instances at the state level) result in increased production levels of degrees at the institutional level. In one study looking at the efficiency of degree production and state higher education policy, Titus (2009a) finds that an infusion of need-based financial aid at the state level produces a greater number of degrees for low-producing institutions. A different study by Titus (2009b) looking at bachelor degree production in relation to state appropriations for higher education found that implicit contracting of institutions as agents with increased funding, produced a greater number of degrees. Supporting the application of the principal-agent theory directly to higher education production within these studies, the importance of longitudinal data to analyze the changes within agents over is key to the current study as it supports inclusion of NSF undergraduate STEM awards for education and workforce development over time.

In reviewing the current research in higher education utilizing principal-agent theory, particularly those studies focused on production, the inclusion of federal STEM funding for academic institutions as a unit of financial capital within the production function is founded. This is important not only to consider specialized funding sources for STEM, but also to determine how these institutions act as agents for the federal goal of increased STEM degree production with particular focus on underrepresented STEM populations (women and URMs).

Consideration of this external capital, in conjunction with institutional capital and labor across time, allows for an increased understanding of the long-run relationship of such funding.

Summary of Chapter II

Despite a notable body of literature focused on student movement through the STEM pipeline, the role of the institution within the production model remains unclear. Of the few studies focused on STEM baccalaureate degree production, the consideration of external funding allocated directly toward STEM education is nonexistent. This chapter addressed how this study, within the framework of the education production function theory and principal-agent theory, may apply a production model to determine not only the institutional characteristics, capital, and labor that predict STEM baccalaureate production, but also the effect of directed external capital. The next chapter will focus on the data sources to answer, within an appropriate statistical model, the question of how institutional and external input affects the overall and demographic-specific baccalaureate degree production within STEM.

CHAPTER III: METHODOLOGY

The focus of the research was to understand the impact of targeted federal grant funding on undergraduate degree production for STEM majors at postsecondary institutions. The institutions for analysis included U.S. public and private four-year postsecondary institutions with available data via IPEDS for the years included in this study, 2003-2012. Targeted federal grant funding for STEM included those awards made by the National Science Foundation with a specific aim for improving undergraduate instruction and human resource development in general. The NSF funding that targets specific populations including women and URMs (defined as students identifying as black/African American, Hispanic/Latino, and American Indian/Alaska Native) are used as primary independent variables and NSF funding for URMs and women are considered separately. For the purpose of this study, all women in STEM are included and therefore there is some overlap in populations for underrepresented groups between women and URMs for those identifying as URM women. The specific questions that guided the research were as follows:

1. Does **NSF award funding** for STEM undergraduate education contribute to the **change in total yearly production of baccalaureate STEM degrees per institution** (between 2003 and 2012) in postsecondary institutions, when **controlling for institutional characteristics** including financial, labor, and institutional capital?

2. Does **NSF award funding for women** in STEM undergraduate education contribute to the **change in yearly total production of women baccalaureate STEM degrees per institution** (between 2003 and 2012) in postsecondary institutions, when **controlling for institutional characteristics** including financial, labor, and institutional capital?

3. Does **NSF award funding for URMs** in STEM undergraduate education contribute to the **change in yearly total production of URM baccalaureate STEM degrees per institution over time** (between 2003 and 2012) in postsecondary institutions, when **controlling for institutional characteristics** including financial, labor, and institutional capital?

4. Does **NSF award funding** for STEM undergraduate education contribute to the **change in yearly ratio of STEM baccalaureate degrees produced to all baccalaureate degrees produced per institution** (between 2003 and 2012) in postsecondary institutions, when **controlling for institutional characteristics** including financial, labor, and institutional capital?

5. Does **NSF award funding for women** in STEM undergraduate education contribute to the **change in yearly ratio of women STEM baccalaureate degrees produced to all STEM baccalaureate degrees produced per institution** (between 2003 and 2012) in postsecondary institutions, when **controlling for institutional characteristics** including financial, labor, and institutional capital?

6. Does **NSF award funding for URMs** in STEM undergraduate education contribute to the **change in yearly ratio of URM STEM baccalaureate degrees produced to all STEM baccalaureate degrees produced per institution** (between 2003 and 2012) in postsecondary institutions, when **controlling for institutional characteristics** including financial, labor, and institutional capital?

Dependent Variables

This study focused on two outcome measures related to baccalaureate degree production, total degrees awarded per institution per year and degree production ratios per institution per year over a 10 year time period from 2003-2012. Two types of production outcomes were included to understand both the overall production of baccalaureate degrees for the focus groups (STEM, women STEM, and URM STEM) and to understand degree production for these groups relative to others within the production function to determine growth of the subsets (STEM baccalaureates awarded within all baccalaureate, women STEM awarded within all STEM, and URM STEM awarded within all STEM). By considering both dependent variable types, NSF funding was applied to concepts of producing more STEM baccalaureate degrees (total) and building STEM programs within institutions (proportion of STEM baccalaureate degrees).

These outcome variables allowed for within-institution measurement as they speak to the overall gross production of STEM degrees by institutions over time and the growth of STEM overall and for underrepresented populations within institutions over time. Finally, the production of STEM degrees' included those academic fields defined in the Institute of Education Sciences (2011) report on STEM awards by state for the years 2001 and 2009 as science, technology, engineering, and mathematics or STEM fields. Their report utilized prescribed definitions by U.S. Immigration and Customs Enforcement (ICE) for STEM programs and included Classification of Instructional Program (CIP) codes related to mathematics, natural sciences, engineering/engineering technologies, and computer/informational sciences. A list of majors and CIP codes utilized in the current study is available in the appendix.

These measures are key to addressing the national call for more STEM baccalaureate awardees by considering the need for greater numbers of STEM degrees overall and the need to have more representative awardees by increasing underrepresented population STEM degree attainment. Specific outcome measures for this study are defined as follows:

Total STEM Baccalaureate Degree Production =
All Baccalaureate Degrees Awarded in STEM fields per institution per year

Total Women STEM Baccalaureate Degree Production =
All Baccalaureate Degrees Awarded to Women (both URM and non-URM) in STEM fields per institution per year

Total URM STEM Baccalaureate Degree Production =
All Baccalaureate Degrees Awarded to URMs (both men and women) in STEM fields per institution per year

STEM Baccalaureate Degree Production Rate =
All Baccalaureate Degrees Awarded in STEM fields per institution per year /
All Baccalaureate Degrees Awarded per institution per year

STEM Women Baccalaureate Degree Production Rate =
All Baccalaureate Degrees Awarded to Women (both URM and non-URM) in STEM fields per institution per year / All Baccalaureate Degrees Awarded in STEM fields per institution per year

STEM URM Baccalaureate Degree Production Rate =
All Baccalaureate Degrees Awarded to URMs (both men and women) in STEM fields per institution per year / All Baccalaureate Degrees Awarded in STEM fields per institution per year

Statistical Model

In order to more clearly understand how institutional inputs, with particular emphasis on federal funding targeted to STEM education, affect the defined production outputs at the institution level, panel data and related analyses were used for this study. Zhang (2010) noted that panel data are particularly important to higher education policy research because of the ability to control for within-subject (within-institution for the current study) differences with data representing variation across time (how the institution performs from year to year) as well as the changes across a period of time (the production change from year one to year ten). In addition, Zhang suggested that there are both statistical and conceptual benefits of the methodology as the statistical procedures account for individual heterogeneity (both observed and unobserved differences within institutions that do not affect all institutions in the same manner) and the findings are applicable to the individual unit (institution, state, etc.) providing a more conceptually meaningful unit for developing policy recommendations. Particularly germane to the study, due to its inclusion of both time-variant and time-invariant variables, is the random effects regression model, defined basically by the following equation:

$$y_{it} = \mu_t + \beta x_{it} + \gamma z_i + a_i + \varepsilon_{it}$$

where y_{it} represents the outcome variable of interest, x_{it} represents time-variant variables, z_i represents time-invariant variables, a_i accounts for a set of random variables with a specific distribution independent of the included variables, and ε_{it} represents the error of each individual at each point in time. Additionally, i and t represent the individual institution and time of measurement, respectively. In the model, the measure of time is an academic year. The model for this study with specific definitions is as follows:

$$y_{it} = \mu_t + \beta_1 x_{it} + \beta_2 x_{it} + \beta_3 x_{it} + \beta_4 x_{it} + \beta_5 x_{it} + \beta_6 x_{it} + \beta_7 x_{it} + \beta_8 x_{it} + \beta_9 x_{it} +$$

$$\beta_{10} x_{it} + \beta_{11} x_{it} + \beta_{12} x_{it} + \beta_{13} x_{it} + \gamma_1 z_i + \gamma_2 z_i + \gamma_3 z_i + \gamma_4 z_i + a_i + \varepsilon_{it}$$

y_{it} = Baccalaureate Degree Production Outcome
degree totals or ratios representing institution 'i' at year 't'

μ_t = Constant

$\beta_1 x_{it}$ = Expenditures for Instruction Per Undergraduate Student FTE (in thousands)
(per institution per year)

$B_2 x_{it}$ = Expenditures for Academic Support Per Undergraduate Student FTE (in thou.)
(per institution per year)

B_3x_{it} = Expenditures for Student Services Per Undergraduate Student FTE (in thou.)
(per institution per year)

B_4x_{it} = Expenditures for Institutional Support Per Undergraduate Student FTE (in thou.)
(per institution per year)

B_5x_{it} = Expenditures for Research Per Total Student FTE (in thou.)
(per institution per year)

B_6x_{it} = Expenditures for Public Services Per Undergraduate Student FTE (in thou.)
(per institution per year)

B_7x_{it} = NSF Undergraduate Award Received (all, women, or URM, as appropriate)
(per institution per year)

B_8x_{it} = Student-to-Faculty Ratio (undergraduate FTE / instructional faculty, non-medical)
(per institution per year)

B_9x_{it} = Total Undergraduate Enrollment for Institution (in hundreds)
(per institution per year)

$B_{10}x_{it}$ = STEM Undergraduate Enrollment (as proportion of Total Ugd. Enrollment)
(per institution per year)

$B_{11}x_{it}$ = Women Undergraduate Enrollment (as proportion of Total Ugd. Enrollment)
(per institution per year)

$B_{12}x_{it}$ = URM Undergraduate Enrollment (as proportion of Total Ugd. Enrollment)
(per institution per year)

$B_{13}x_{it}$ = Average Incoming SAT Score
(per institution per year)

$\gamma_1 z_i$ = HBCU institution status in 2012
(per institution)

$\gamma_2 z_i$ = Doctoral institution type in 2012
(per institution)

$\gamma_3 z_i$ = Master's institution type in 2012
(per institution)

$\gamma_3 z_i$ = Women's College status in 2012
(per institution for private institutions only)

$a_i + \varepsilon_{it}$ = Model error terms

The random effects model is appropriate, based upon application of panel data and the presence of time-varying and time-invariant variables, over a series of panel data (Allison, 2009). Allison notes that the main difference of fixed and random effects models is the ability to include time-invariant predictors in a model when they are known to be related to the outcome of study. Based on the literature review of variables such as institution type, HBCUs, and Women's Colleges, a model with the ability to control for influential time-invariant predictors while estimating the time-varying effects by institution is essential, thus the reason for selection in the current study. Multicollinearity was tested utilizing the variance inflation factor (VIF) to determine the relationship of independent variables to one another. It is important to test for multicollinearity as strong correlations between independent variables can affect the interpretation of their related coefficients within the model. Due to this study's interest in how individual predictors perform, (i.e. NSF Funding), determining that independent variables meet reasonable multicollinearity thresholds is essential. A VIF standard of 10 or greater was applied to the findings to identify multicollinearity issues by model (Marasinghe & Kennedy, 2008). Practically, SAS 9.4 was utilized to conduct these analyses utilizing the 'proc mixed' function to apply a random effects model and 'proc reg' to determine VIF values.

As has been previously noted, the focus of the independent variables was to include relevant measures of institutional capital, financial capital, labor resources, and institutional characteristics in the education production function model to determine if the presence of NSF award funding over time changes the production function of STEM baccalaureate degrees within institutions. Independent variables were selected to account for known predictors of degree production and allow for an informed analysis of the relationship of NSF funding awards for STEM education to the production of STEM degrees. By accounting for the factors informed by the conceptual framework applied to this study, many of which are empirically-examined predictors of baccalaureate degree production, NSF funding can be measured as a predictor holding other influential variables constant to best determine the impact of this external funding source.

In addition to a final model built upon the theoretical framework and research-based predictors of degree production, sequential model analysis was conducted to understand how the inclusion of independent variables into the model changed the NSF funding factor. Each sequential analysis includes four models with differing independent variable inclusion and they are as follows: NSF funding only; NSF funding and time-varying variables (expenditures, size, student to faculty ratio, SAT average, percent of enrollment for subpopulations); NSF funding with time-varying and time-invariant (HBCU status, Doctoral, Master's, and Women's College status for private institutions); and the complete model including NSF funding, time-varying, time-invariant, and year variables. The goal of the sequential analysis was to determine whether or not NSF funding changes significance in the model as additional variables influencing the outcome were controlled. The sequential model analyses are included in the appendix.

Data Sources

The data utilized in this study covers the most recently available 10 year period (2003-2012) for all variables included in the applied models. Supplementing IPEDS data to gain a measure of NSF undergraduate award support capital, financial funding for science and engineering undergraduate education as reported through the NSF Awards Abstract Database are included. Utilizing the grant search feature available through the NSF data site, yearly award amounts (based on the fiscal year) may be obtained by individual institutions of receipt focused on undergraduate education and workforce development initiatives at the college/university level. Among the groups targeted for intervention, ethnic minorities and other underrepresented groups within STEM (women) are frequently noted as part of the award abstract allowing for data coding to determine funding for underrepresented STEM groups, specifically with regard to grant awards coded in Undergraduate Education (DUE) and Human Resource Development (HRD) subgroups as outlined by the Directorate for Education and Human Resources (EHR) within the National Science Foundation (NSF, 2014b). Three forms of NSF undergraduate award data were available for use in the model – support for all students, support directed toward URM initiatives, and support directed toward women in STEM. These data groups were determined by researcher analysis of abstracts for STEM awards, focusing on language outlining funding purpose for women, URMs, underrepresented STEM groups, and STEM education. Institutions were coded as having NSF funding for general STEM, women, and/or URMs per year, if they received any award in these categories. Analysis of these NSF abstracts allowed for the formation of dichotomous variables for NSF funding. NSF awards targeted for multiple subpopulations within the underrepresented STEM population (such as women and URMs) were included in both the NSF funding for women variable and the NSF funding for URMs variable in the related year.

Financial variables related to institutional expenditures and NSF award support for science and engineering undergraduate instruction and education within the institution were applied with a lagged approach utilizing funding values four years prior, (2000-2009) to allow for infusion of financial inputs across the production landscape. The model applied a four year lag for financial inputs to address the common period of time (4 years) for baccalaureate completion as defined by a number of data reporting sources (e.g., IPEDS, Voluntary System of Accountability, Student Achievement Measure). The purpose of applying a four year lag was to capture the relationship of NSF funding application to STEM efforts at institutions, a process that requires time for both implementation and for the possibility of related degree completion by affected students. Institutional funding also had to be lagged to provide a comparable measure of financial resources at the time the institution received NSF funding, where appropriate. The primary data source for this study was the Integrated Postsecondary Education Data System (IPEDS), a collection of annual surveys of colleges and universities initiated by the National Center for Education Statistics (NCES). In addition, financial capital represented by NSF undergraduate award support for STEM education was obtained through data sources from the U.S. National Science Foundation (NSF) Award Abstracts Database.

The utilization of IPEDS for this specific course of research was optimal due to the focus of data on institutional characteristics, inputs, and outputs; as well as the ability to consider these variables over the course of multiple years to determine longitudinal effects. The broad concepts, capital and labor inputs, for the institutional influence of the education production function were represented through data collection of institutional expenditures, student-to-faculty ratio, overall student enrollment, SAT (or equivalent ACT) scores of incoming students, and STEM enrollment, among others. Likewise, the necessary data for assessing the output in the form of production totals and production rates overall, by women awardees, and by URM awardees are provided annually. Finally, IPEDS data are required by institutions participating in Title IV and thus, provide a consistent and near complete set of data for ten-year trend analyses on public postsecondary institutions.

Table 1 provides a complete overview of all variables included in the study. In addition to the general definition of the variable, the application of the variable to the conceptual framework and data source are provided.

Table 1. Variables Included in Statistical Model

Variable **(Source)**	Variable Type: Dependent (D) or Independent (I) and Theoretical Concept
Total Baccalaureate Degrees Awarded STEM Per institution *Number of STEM Degrees per Year* **(IPEDS)**	D – Production Output
STEM Baccalaureate Degree Production Rate Per Institution *(Percent Measured by Number of STEM degrees/All degrees)* **(IPEDS)**	D – Production Output
Total STEM Baccalaureate Degrees Awarded Women Per Institution *Number of STEM Degrees for Women per Year* **(IPEDS)**	D – Production Output
Women STEM Baccalaureate Degree Production Rate Per Institution *(Percent Measured by Number of Women STEM degrees/All STEM degrees)* **(IPEDS)**	D – Production Output
Total STEM Baccalaureate Degrees Awarded URMs Per Institution *Number of STEM Degrees for URMs per Year* **(IPEDS)**	D – Production Output
URM STEM Baccalaureate Degree Production Rate Per Institution *(Percent Measured by Number of URM STEM degrees/All STEM degrees)* **(IPEDS)**	D – Production Output
NSF Undergraduate Award (all, women, or URM, as appropriate) *1=Institution Received NSF Award, 0=No NSF Award* **(NSF & IPEDS)**	I – Financial Capital

Expenditures for Instruction per Undergraduate FTE *Reported in Thousands of Dollars* **(IPEDS)**	I – Financial Capital
Expenditures for Academic Support per Undergraduate FTE *Reported in Thousands of Dollars* **(IPEDS)**	I – Financial Capital
Expenditures for Student Services per Undergraduate FTE *Reported in Thousands of Dollars* **(IPEDS)**	I – Financial Capital
Expenditures for Institutional Support per Undergraduate FTE *Reported in Thousands of Dollars* **(IPEDS)**	I – Financial Capital
Expenditures for Research per Total FTE *Reported in Thousands of Dollars* **(IPEDS)**	I – Financial Capital
Expenditures for Public Services per Total FTE *Reported in Thousands of Dollars* **(IPEDS)**	I – Financial Capital
Student-to-Faculty Ratio *Percent Measured by Number of Undergraduate Student FTE Divided by Tenure/Tenure Track Faculty FTE* **(IPEDS)**	I – Labor
Total Undergraduate Enrollment *Reported in Hundreds of Students* **(IPEDS)**	I – Institutional capital
% Undergraduate Enrollment STEM *Percent Measured by Enrollment in Undergraduate STEM programs Divided by Undergraduate Enrollment* **(IPEDS)**	I – Institutional capital

% Undergraduate Enrollment Women *Percent Measured by Enrollment of Women Divided by Undergraduate Enrollment* **(IPEDS)**	I – Institutional capital
% Undergraduate Enrollment URM *Percent Measured by Enrollment of URMs Divided by Undergraduate Enrollment* **(IPEDS)**	I – Institutional capital
Average SAT (avg. 25th/75th percentiles) *Actual SAT average value as reported to IPEDS* **(IPEDS)**	I – Institutional Capital
Doctoral Institution *1 = Doctoral, 0 = Other* **(IPEDS)**	I – Institutional Capital
Master's Institution *1 = Master's, 0 = Other* **(IPEDS)**	I – Institutional Capital
HBCU Institution *1 = HBCU, 0 = Other* **(IPEDS)**	I – Institutional Capital
Women's College (private institutions only) *1 = Women's College, 0 = Other* **(IPEDS)**	I – Institutional Capital

Data transformations were performed for expenditure variables, SAT profile, undergraduate enrollment, and institution types. Transformation of expenditure variables was employed to allow for a more direct relationship of expenditures to undergraduate education utilizing a transformation procedure proposed by Pike (2015). This procedure allowed for expenditures per undergraduate FTE to be reported utilizing IPEDS data, important to this study as the outcome variables are related to undergraduate degree production only. Pike's transformation methodology approaches the total expenditures for instruction, academic support, student services, and institutional support by first dividing by total FTE for the corresponding year, multiplying the result by the graduate FTE & 1.3, and then subtracting the result from the total expenditures. This value was then divided by 1,000 to make the variable more easily interpretable within the context of the model. The purpose of this transformation is to weigh graduate students heavier as they trend toward greater expense in these areas (Pike, 2015) and get a more reasonable estimate of undergraduate expenses to determine how NSF funding affects the intended population of students by institution. Additionally, research and public service expenditures were divided by total student FTE and divided by 1,000. These expenditures more directly relate to the overall institution and thus were not calculated for undergraduate FTE. Total undergraduate enrollment was included and divided by 100 to provide a more easily interpretable variable within the model. Additionally, SAT data from IPEDS reported as 25th and 75th percentile scores for both the Verbal and Math portions, were analyzed to provide a proxy for SAT total average. Utilizing a similar procedure as Zhang (2009), the midpoint of the 25th percentile scores and 75th percentile SAT scores (combined Verbal and Math) were determined to provide the SAT total average proxy encompassing both Verbal and Math SAT outcomes. Finally, dichotomous time-invariant variables such as institutional type (Doctoral/Master's) and institutions serving specific communities (HBCUs and Women's Colleges) were dummy coded.

Limitations of Data

As with any study, there are limitations of the data sources utilized for this research study. These limitations include lack of defined STEM program funding allocation to individual programs, cohort graduation rate data unavailable by individual Classification of Instructional Program (CIP) code by gender and ethnicity, and the need to employ panel data analyses utilizing random effects modeling due to both time-variant and time-invariant independent variables. Further explanation of these limitations is discussed below.

Limitations of university/college funding data from the National Science Foundation include (NSF) the lack of information on allocation to specific endeavors within the fields making up STEM; science, technology, engineering, and mathematics. While this study has a primary focus on the overall production of baccalaureate degrees in all STEM fields at the institution level, both in total and for underrepresented groups, the lack of information on funding allocations to specific fields within STEM limits the discipline-specific applicability of the findings. Discipline-specific production within STEM can be important as each field has a unique focus and the potential to use federal funding differently within the discipline is a reality. Considering the general focus of the current study and the likely accountability requirements to take place at the institution level (not STEM department level) for federal funding sources, this is a minor limitation.

Despite the wealth of longitudinal data available at the institutional level in IPEDS, graduation rates for defined cohorts by academic discipline (CIP codes) are not available. This is noteworthy as many studies focused on the general baccalaureate education production function utilize the graduation rate of the defined incoming first-time freshman cohort as the outcome variable (Archibald & Feldman, 2008; Hurtado, Eagan, & Hughes, 2012; Ryan, 2004; Scott, Bailey, & Kienzl, 2006; Webber & Ehrenberg, 2010; Zhang, 2009). The inability to build on those graduation rate studies to have more comparative and supportive findings to the current body of research is a limitation. However, despite graduation rate serving more often as the production outcome, the focus of this study on total degree production and proportion growth within underrepresented STEM populations (women and URMs) more directly addresses the issues of need for more degrees and more diversity within the STEM professions. In addition, total production is presented as a measure of quantity (more degrees) while growing graduation rates for cohorts of first-time college students could be defined as a measure of quality (increasing proportion of a defined population). The focus of the current study is on production as a measure of quality only. By looking at the overall production, the importance of students not included in first-time cohorts such as transfer students and those changing their initial program of enrollment may also be included to determine the true, overall STEM production quotient.

Finally, the nature of the longitudinal data sources and panel data approach of the random effects regression model provide a limitation to applicability of the findings. These data, analyzed within the model, suggest outcomes pertinent to how changes within specific institutions affect the production quotient (Allison, 2009). The need to include both time-varying and time-invariant variables within the model limits the approaches for panel data modeling. While this is not problematic for the institutional focus and purpose of this study, to determine how institutional characteristics including federal STEM funding for education affect baccalaureate degree production in the STEM fields, it could be considered a limitation as it does assume a lack of correlation between observed and unobserved variables in the model which is likely an unrealistic proposition for this study.

These data limitations are important to note and consider through the research process, but they do not hinder the general research model and utilization of data to answer the research questions.

Summary of Chapter III

This chapter described the independent and dependent variables, statistical model, and data sources to be utilized in determining the relationship of institutional capital, financial capital (institutional and external), labor resources, and institutional characteristics to baccalaureate degree production in the STEM fields, both generally and within underrepresented demographic groups. The primary data sources, IPEDS and the NSF Award Abstract Database, contain the required data to apply both the education production function theory and principal-agent theory to the research questions. In the following dissertation chapters, the results from the application of the methodology, discussion and limitation of findings, and future research are examined.

CHAPTER IV: RESULTS

This study focused on the production of STEM baccalaureate degrees at U.S. postsecondary institutions, particularly for underrepresented ethnic minorities (URMs) and women. More specifically, the objective was to determine if NSF funding for STEM education affects STEM degree production when holding other related institutional factors constant. This goal required a method of analyzing both within institution changes (utilizing time-varying variables) and between institution changes (utilizing time-invariant variables) to account for factors influencing change across time within the institutions and characteristics of institutions with differing STEM degree production patterns in total, for women and for URMs. Application of random effects regression modeling allowed for determination of significant time-variant (those variables that changed over time within an institution) and time-invariant (those variables that would not change over time within an institution) predictors for the purpose of effective policy development.

STEM Degree Production Totals and Rates

The research design for measuring both production totals and production rates among all, women, and URM STEM degree awardees resulted in six unique outcome variables. The dependent variables were established across a longitudinal span of 10 years from 2003-2012 and are as follows: total yearly STEM baccalaureate degrees awarded per institution, yearly institutional production rate of STEM baccalaureate degrees, total yearly STEM baccalaureate degrees awarded to women per institution, yearly institutional production rate of STEM baccalaureate degrees for women, total yearly STEM baccalaureate degrees awarded to URMs per institution, and yearly institutional production rate of STEM baccalaureate degrees for

URMs. As was previously mentioned in Chapter 3, the different financial reporting methodology required for public and private institutions to IPEDS requires separate analyses by institutional control, creating two sets of dependent variables for consideration. Table 2 shows the mean and standard deviation of each dependent variable per year, separated by public institutions (N=498) and private institutions (N=826).

Table 2. Degree Totals and Production Rates Examined Longitudinally by Institutional Control

Dependent	2003		2004		2005		2006		2007	
Variables	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*
PUBLIC										
Total STEM Degrees	298.55	*392.51*	301.58	*404.41*	308.42	*412.53*	312.41	*416.66*	316.28	*421.94*
STEM Production Rate	0.15	*0.10*	0.15	*0.10*	0.15	*0.10*	0.15	*0.10*	0.15	*0.10*
Total Women STEM Degrees	104.60	*132.58*	105.10	*136.31*	106.77	*140.64*	108.88	*142.16*	109.51	*143.53*
Women STEM Production Rate	0.10	*0.08*	0.10	*0.08*	0.10	*0.08*	0.10	*0.08*	0.10	*0.08*
Total URM STEM Degrees	39.00	*55.60*	39.79	*56.39*	40.48	*57.87*	41.40	*59.39*	41.38	*60.07*
URM STEM Production Rate	0.13	*0.10*	0.13	*0.10*	0.12	*0.10*	0.12	*0.10*	0.12	*0.10*
PRIVATE										
Total STEM Degrees	80.29	*131.20*	79.73	*130.57*	78.21	*129.52*	77.01	*127.61*	78.13	*134.72*
STEM Production Rate	0.14	*0.12*	0.13	*0.11*	0.13	*0.11*	0.13	*0.11*	0.13	*0.11*
Total Women STEM Degrees	32.89	*42.89*	32.99	*42.88*	32.20	*42.26*	32.22	*42.29*	32.44	*44.06*
Women STEM Production Rate	0.11	*0.11*	0.11	*0.10*	0.10	*0.10*	0.10	*0.10*	0.10	*0.10*
Total URM STEM Degrees	9.52	*21.70*	9.51	*21.43*	9.40	*21.04*	8.91	*20.14*	9.18	*19.58*
URM STEM Production Rate	0.11	*0.14*	0.12	*0.13*	0.10	*0.12*	0.10	*0.12*	0.10	*0.12*

(table continues)

Table 2. Continued

Dependent Variables	2008 Mean	2008 *SD*	2009 Mean	2009 *SD*	2010 Mean	2010 *SD*	2011 Mean	2011 *SD*	2012 Mean	2012 *SD*
PUBLIC										
Total STEM Degrees	319.31	*424.48*	326.23	*434.79*	343.16	*462.10*	363.93	*492.28*	390.01	*519.56*
STEM Production Rate	0.14	*0.10*	0.14	*0.10*	0.15	*0.10*	0.15	*0.10*	0.15	*0.10*
Total Women STEM Degrees	110.58	*144.37*	112.65	*147.77*	118.17	*155.90*	125.72	*167.78*	133.87	*177.06*
Women STEM Production Rate	0.09	*0.08*	0.10	*0.08*	0.10	*0.08*	0.10	*0.08*	0.10	*0.08*
Total URM STEM Degrees	42.80	*63.18*	44.55	*65.28*	46.99	*69.59*	50.34	*76.18*	55.39	*83.53*
URM STEM Production Rate	0.12	*0.10*	0.12	*0.11*	0.12	*0.10*	0.12	*0.10*	0.12	*0.09*
PRIVATE										
Total STEM Degrees	78.66	*136.22*	80.20	*139.01*	84.67	*149.14*	88.04	*152.10*	93.35	*159.42*
STEM Production Rate	0.12	*0.11*	0.12	*0.11*	0.13	*0.11*	0.13	*0.11*	0.14	*0.12*
Total Women STEM Degrees	32.74	*44.63*	33.73	*46.16*	35.79	*50.89*	37.38	*52.44*	40.65	*56.54*
Women STEM Production Rate	0.10	*0.10*	0.10	*0.10*	0.11	*0.11*	0.11	*0.11*	0.12	*0.11*
Total URM STEM Degrees	8.99	*18.46*	9.19	*18.61*	9.74	*20.02*	10.20	*20.00*	11.27	*21.93*
URM STEM Production Rate	0.10	*0.12*	0.10	*0.11*	0.10	*0.12*	0.11	*0.12*	0.11	*0.12*

A review of average outcomes related to total degree production and production rates for STEM baccalaureate degrees in general and for underrepresented populations across the years in Table 2 reveals some common patterns. For public institutions the production rates remain fairly stable across the 10 year period of study (2003-2012) for all STEM awardees, women, and URMs. The average total number of degrees by public institution shows growth during the 10 year period for all STEM, women, and URMs; however, there appears to be greater growth from year to year near the end of the period of inquiry. While standard deviations are large for the averages presented, the inclusion of undergraduate enrollment and consideration of Doctoral, Master's, and Baccalaureate institution classifications as independent variables will help account for the differences in overall production by institution. In addition, the interest in this analysis is primarily within-institution changes over time and, thus, the institution performance in relation to other institutions is not of primary focus.

Private institution outcomes were quite similar to those of the public institution with production rates for all STEM, women, and URMs staying fairly stable across years. When looking at the total average STEM degree production rates at private institution, there appears to be a slight dip in the average during the period of study. The total degree production for all STEM students, women in STEM, and URMs in STEM reveals growth during the period of study with greater growth in the later years, similar to public institutions. The URM STEM degree production averages for private institutions were larger as noted; however, the growth is at a much less prominent rate as compared to all STEM awardees and women receiving STEM baccalaureate degrees. Similarly, standard deviations are large but the inclusion of undergraduate enrollment and Doctoral, Master's, and Baccalaureate status in the model help temper these across institution effects.

NSF Funding as Key Independent Variable

The key variable of inquiry in the current study is the NSF funding awards for STEM undergraduate education. NSF funding was coded to allow for analysis by three categories of NSF funding including any institution receiving STEM undergraduate education funding, institutions receiving NSF funding for STEM undergraduate education focused on women or general underrepresented STEM population initiatives, and institutions receiving NSF funding for STEM undergraduate education focused on URMs (or general underrepresented STEM population initiatives). Table 3 provides an overview of the number of institutions receiving an

NSF funding award, by year, for all awards, women, and URMs. Institutions receiving more than one award in a year are counted once in this table.

Table 3. Overall Institution NSF Funding Awards and Percent of All Institutions by All, Women, and URM

NSF STEM AWARD CATEGORY	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
All NSF Awards (N)	54	64	77	77	44	73	21	88	111	122
% Institutions Receiving NSF Award	4.08%	4.83%	5.82%	5.82%	3.32%	5.51%	1.59%	6.65%	8.38%	9.21%
NSF Awards for Women (N)	22	27	21	36	26	45	9	40	51	65
% Institutions Receiving NSF Award for Women	1.66%	2.04%	1.59%	2.72%	1.96%	3.40%	0.68%	3.02%	3.85%	4.91%
NSF Awards for URMs (N)	37	40	21	43	30	55	9	61	75	83
% Institutions Receiving NSF Award for URMs	2.79%	3.02%	1.59%	3.25%	2.27%	4.15%	0.68%	4.61%	5.66%	6.27%

Evident from the table is that funding has not been on a steady increase throughout all 10 years, but has increased over time. More specifically, the percentage of institutions receiving funding increased for all, women and URM awards from 2003 to 2012. The increased presence of NSF funding, with a slight decline in the middle years, suggests that should NSF funding have a significant relationship to degree production, it will be a significant predictor of growth in the dependent variables.

Due to the need for separate analysis by public and private institutions, it is also important to look at the awarding patterns for each of the types of NSF funding (all, women, and URM) by public and private status. Table 4 provides the total count and proportion of institutions receiving an NSF award for STEM undergraduate education by public and private institution status.

Table 4. Overall Institution NSF Funding for All and Percent by Institution Control & Type

PUBLIC & PRIVATE NSF AWARD BY INSTITUTION TYPE	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
NSF Awards DOCTORAL PUBLIC (N)	32	30	26	31	19	34	11	39	51	53
% DOCTORAL Institutions Receiving NSF Award PUBLIC	18.7%	17.5%	15.2%	18.1%	11.1%	19.9%	6.4%	22.8%	29.8%	31.0%
NSF Awards MASTER'S PUBLIC (N)	13	14	26	22	14	17	3	24	27	29
% MASTER'S Institutions Receiving NSF Award PUBLIC	5.0%	5.4%	10.0%	8.5%	5.4%	6.5%	1.2%	9.2%	10.4%	11.2%
NSF Awards BACHELOR PUBLIC (N)	0	3	3	3	3	2	1	1	4	1
% BACHELOR Institutions Receiving NSF Award PUBLIC	0.0%	4.5%	4.5%	4.5%	4.5%	3.0%	1.5%	1.5%	6.0%	1.5%
NSF Awards TOTAL PUBLIC (N)	**45**	**47**	**55**	**56**	**36**	**53**	**15**	**64**	**82**	**83**
% TOTAL Institutions Receiving NSF Award PUBLIC	**9.0%**	**9.4%**	**11.0%**	**11.2%**	**7.2%**	**10.6%**	**3.0%**	**12.9%**	**16.5%**	**16.7%**
NSF Awards DOCTORAL PRIVATE (N)	4	6	4	1	2	2	2	8	7	5
% DOCTORAL Institutions Receiving NSF Award PRIVATE	4.1%	6.1%	4.1%	1.0%	2.0%	2.0%	2.0%	8.2%	7.1%	5.1%
NSF Awards MASTER'S PRIVATE (N)	4	7	8	14	5	11	1	8	10	21
% MASTER'S Institutions Receiving NSF Award PRIVATE	1.2%	2.2%	2.5%	4.3%	1.5%	3.4%	0.3%	2.5%	3.1%	6.5%
NSF Awards BACHELOR PRIVATE (N)	1	4	10	6	1	7	3	8	12	13
% BACHELOR Institutions Receiving NSF Award PRIVATE	0.2%	1.0%	2.5%	1.5%	0.2%	1.7%	0.7%	2.0%	3.0%	3.2%
NSF Awards TOTAL PRIVATE (N)	**9**	**17**	**22**	**21**	**8**	**20**	**6**	**24**	**29**	**39**
% TOTAL Institutions Receiving NSF Award PRIVATE	**1.1%**	**2.1%**	**2.7%**	**2.5%**	**1.0%**	**2.4%**	**0.7%**	**2.9%**	**3.5%**	**4.7%**

A review of the table suggests that while public institutions received more NSF awards for general STEM undergraduate education per year than private institutions, the percentage of institutions receiving funding increased at a greater rate in private institutions (approximately four times more) than private institutions (almost two times more). Table 5 provides similar information for NSF awards for women.

Table 5. Overall Institution NSF Funding for Women and Percent by Institution Control & Type

PUBLIC & PRIVATE NSF AWARD FOR WOMEN BY INSTITUTION TYPE	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
NSF Awards for Women DOCTORAL PUBLIC (N)	16	14	5	14	10	21	5	16	25	30
% DOCTORAL Institutions Receiving NSF Award for Women PUBLIC	9.4%	8.2%	2.9%	8.2%	5.8%	12.3%	2.9%	9.4%	14.6%	17.5%
NSF Awards for Women MASTER'S PUBLIC (N)	3	7	9	11	7	9	2	11	13	10
% MASTER'S Institutions Receiving NSF Award for Women PUBLIC	1.2%	2.7%	3.5%	4.2%	2.7%	3.5%	0.8%	4.2%	5.0%	3.8%
NSF Awards for Women BACHELOR PUBLIC (N)	0	1	2	0	3	1	0	0	1	0
% BACHELOR Institutions Receiving NSF Award for Women PUBLIC	0.0%	1.5%	3.0%	0.0%	4.5%	1.5%	0.0%	0.0%	1.5%	0.0%
NSF Awards for Women TOTAL PUBLIC (N)	**19**	**22**	**16**	**25**	**20**	**31**	**7**	**27**	**39**	**40**
% TOTAL Institutions Receiving NSF Award for Women PUBLIC	**3.8%**	**4.4%**	**3.2%**	**5.0%**	**4.0%**	**6.2%**	**1.4%**	**5.4%**	**7.8%**	**8.0%**
NSF Awards for Women DOCTORAL PRIVATE (N)	3	1	0	1	1	1	0	4	4	2
% DOCTORAL Institutions Receiving NSF Award for Women PRIVATE	3.1%	1.0%	0.0%	1.0%	1.0%	1.0%	0.0%	4.1%	4.1%	2.0%
NSF Awards for Women MASTER'S PRIVATE (N)	0	3	1	7	4	7	0	6	4	14
% MASTER'S Institutions Receiving NSF Award for Women PRIVATE	0.0%	0.9%	0.3%	2.2%	1.2%	2.2%	0.0%	1.9%	1.2%	4.3%
NSF Awards for Women BACHELOR PRIVATE (N)	0	1	4	3	1	6	2	3	4	9
% BACHELOR Institutions Receiving NSF Award for Women PRIVATE	0.0%	0.2%	1.0%	0.7%	0.2%	1.5%	0.5%	0.7%	1.0%	2.2%
NSF Awards for Women TOTAL PRIVATE (N)	**3**	**5**	**5**	**11**	**6**	**14**	**2**	**13**	**12**	**25**
% TOTAL Institutions Receiving NSF Award for Women PRIVATE	**0.4%**	**0.6%**	**0.6%**	**1.3%**	**0.7%**	**1.7%**	**0.2%**	**1.6%**	**1.5%**	**3.0%**

The table suggests that awards for women grew over the ten year timeframe, but relatively few private institutions received NSF funding targeted toward STEM undergraduate education for women. Finally, Table 6 provides information for NSF awards for URMs.

Table 6. Overall Institution NSF Funding for URM and Percent by Institution Control & Type

PUBLIC & PRIVATE NSF AWARD FOR URMs BY INSTITUTION TYPE	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
NSF Awards for URMs DOCTORAL PUBLIC (N)	23	19	6	17	11	28	6	27	33	40
% DOCTORAL Institutions Receiving NSF Award for URMs PUBLIC	13.5%	11.1%	3.5%	9.9%	6.4%	16.4%	3.5%	15.8%	19.3%	23.4%
NSF Awards for URMs MASTER'S PUBLIC (N)	8	10	11	14	8	12	2	19	21	15
% MASTER'S Institutions Receiving NSF Award for URMs PUBLIC	3.1%	3.8%	4.2%	5.4%	3.1%	4.6%	0.8%	7.3%	8.1%	5.8%
NSF Awards for URMs BACHELOR PUBLIC (N)	0	1	2	0	3	2	0	0	3	1
% BACHELOR Institutions Receiving NSF Award for URMs PUBLIC	0.0%	1.5%	3.0%	0.0%	4.5%	3.0%	0.0%	0.0%	4.5%	1.5%
NSF Awards for URMs TOTAL PUBLIC (N)	**31**	**30**	**19**	**31**	**22**	**42**	**8**	**46**	**57**	**56**
% TOTAL Institutions Receiving NSF Award for URMs PUBLIC	**6.2%**	**6.0%**	**3.8%**	**6.2%**	**4.4%**	**8.4%**	**1.6%**	**9.2%**	**11.4%**	**11.2%**
NSF Awards for URMs DOCTORAL PRIVATE (N)	3	4	0	1	2	2	1	4	6	4
% DOCTORAL Institutions Receiving NSF Award for URMs PRIVATE	3.1%	4.1%	0.0%	1.0%	2.0%	2.0%	1.0%	4.1%	6.1%	4.1%
NSF Awards for URMs MASTER'S PRIVATE (N)	3	5	1	9	5	7	0	5	5	16
% MASTER'S Institutions Receiving NSF Award for URMs PRIVATE	0.9%	1.5%	0.3%	2.8%	1.5%	2.2%	0.0%	1.5%	1.5%	5.0%
NSF Awards for URMs BACHELOR PRIVATE (N)	0	1	1	2	1	4	0	6	7	7
% BACHELOR Institutions Receiving NSF Award for URMs PRIVATE	0.0%	0.2%	0.2%	0.5%	0.2%	1.0%	0.0%	1.5%	1.7%	1.7%
NSF Awards for URMs TOTAL PRIVATE (N)	**6**	**10**	**2**	**12**	**8**	**13**	**1**	**15**	**18**	**27**
% TOTAL Institutions Receiving NSF Award for URMs PRIVATE	**0.7%**	**1.2%**	**0.2%**	**1.5%**	**1.0%**	**1.6%**	**0.1%**	**1.8%**	**2.2%**	**3.3%**

Similar to the patterns for all NSF funding awards for STEM undergraduate education and NSF funding awards for women, more funding for STEM undergraduate education to URMs has been awarded to public institutions for URMs, than private. However, both have seen growth in these areas between 2003 and 2012. The NSF awards patterns described in this section are important to the overall model as the presence of NSF funding is a key focus of the current study. The following sections describe the findings for each model, with particular attention paid to how NSF funding affects the outcomes.

Descriptive Statistics for Independent Variables

The models utilized in the current study encompass a number of related variables to undergraduate degree production in general, and STEM degree production specifically. Descriptive statistics including mean, standard deviation, minimum values, and maximum values, are included by year in the Appendix for public institutions (Table 15) and private institutions (Table 16). In general, unexpected differences in means were not observed for public or private institutions across time with respect to time-varying variables and standard deviations were large suggesting that there are differences between institutions in each category (public/private). This finding helps to support the application of the random effects model to determine the effects of within-institution changes, not just focus on the expected differences between institutions of varying types.

Table 15 in the Appendix specifically focuses on the descriptive statistics for the public institutions between the years of interest in the current study, 2003-2012. Mean values for NSF awards did increase over time, specifically for URMs where it almost doubled between 2003 and 2012. Greater detail on NSF funding, as a key independent variable, is provided in the following section. Means for expenditure categories grew modestly across time, with notably large standard deviations suggesting that spending for IPEDS categories varies considerably among public institutions. Other time-varying variables including student-to-faculty ratio, proportions of students of specific demographics enrolled, and SAT average held fairly constant over time. The mean of the value for size of enrollment did grow over time, again with a fairly large standard deviation suggesting great variation across public institutions. Finally, the time-invariant variables focused on HBCU status and the type of institution (Bachelor, Master's, and Doctoral) did not show variance due to their inclusion as static variables with one value for all years included.

Table 16 in the Appendix specifically focuses on the descriptive statistics for the private institutions for the years of interest in the current study, 2003-2012. Mean values for NSF awards did experience an increase, albeit minimally, between 2003 and 2012. Greater detail on NSF funding as a key independent variable is provided in the following section. Means for expenditure categories grew modestly across time, with notably large standard deviations suggesting that spending for IPEDS categories varies considerably among private institutions, similar to public institutions. Other time-varying variables including size of enrollment, student-to-faculty ratio, proportions of students of specific demographics enrolled, and SAT average held fairly constant over time. Finally, the time-invariant variables focused on HBCU and Women's College status and the type of institution (Bachelor, Master's, and Doctoral) did not show variance due to their inclusion as static variables with one value for all years included.

The growth of NSF funding between 2003 and 2012 for both public and private institutions is important to the application of this variable as a key focus in this study. The following section will explore this variable more thoroughly in general and within public and private institutions separately.

NSF Funding Relationship to Total Baccalaureate STEM Degree Production (Number of Degrees Awarded)

Testing of the random effects model for total STEM baccalaureate degree production by institution indicated there was a statistically significant relationship between total STEM degree production and the overall collection of independent variables included in the model for public institutions (Wald $\chi^2 = 14.08$, $p < .001$) and private institutions (Wald $\chi^2 = 17.48$, $p < .001$). The variance inflation factors (VIFs) for independent variables were well below 10, indicating a reasonable level of multicollinearity for both models. Table 7 lists the results from the random effects model for total STEM degree production by institution, including coefficients and standard errors for each independent variable. Bolded results indicate statistically significant effects ($p < 0.05$).

Of particular interest for the present study, the presence of an NSF award for STEM education was also positively related to the total number of STEM baccalaureate degrees produced by institution among private institutions. This finding indicates that the presence of NSF funding, a shift from not receiving funding to receipt of funding, results in an average increase of 8.9 STEM baccalaureate degrees within the private institution. In an effort to more clearly understand the relationship of the model design to NSF award as a key independent variable, a series of four models were run for both public and private institutions to illustrate the change in relationship of NSF award as additional independent variables enter the model. The Appendix contains two tables for public (Table 17) and private (Table 18) institutions with four models to predict the total number of STEM degrees awarded per institution. Groupings of independent variables included in the four models are as follows: NSF award only, NSF award/time-varying, NSF award/time-varying/time-invariant, and NSF award/time-varying/time-invariant/year (complete model). Findings focused on the complete model (Table 7) will be discussed below.

Table 7. Random Effects Model for Total STEM Degree Production

Institutional Characteristics (IVs)	**Public Institutions**		**Private Institutions**		**VIF**	
	β	*Std. Err.*	*β*	*Std. Err.*	*Public*	*Private*
NSF Award Received	*2.398500*	*3.146200*	**8.876300**	**1.850100**	1.072	1.023
Expenditures Instruction	**8.848000**	**1.455400**	**0.514600**	**0.139700**	3.181	3.659
Expenditures Academic Support	*-2.685000*	*1.877100*	**1.196100**	**0.372600**	2.002	1.728
Expenditures Student Services	**-27.223300**	**5.478800**	*-0.542400*	*0.451100*	1.326	1.962
Expenditures Institutional Support	**-9.995800**	**2.692700**	*-0.220000*	*0.247400*	1.733	2.063
Expenditures Research	**0.056670**	**0.008550**	**0.028930**	**0.002033**	3.098	2.109
Expenditures Public Services	*0.034130*	*0.023740*	**0.030620**	**0.007082**	1.450	1.132
Size/Total Enrollment	**2.902700**	**0.090180**	**1.192300**	**0.070780**	2.329	1.955
Student to Faculty Ratio	**-5.602900**	**0.760500**	*0.185400*	*0.113500*	1.492	1.280
SAT Average	**0.261500**	**0.037190**	**0.057420**	**0.008245**	2.900	2.741
Percent STEM Enrollment	**675.160000**	**57.725900**	**69.772100**	**9.587300**	2.592	1.553
Percent Women Enrollment	**-212.380000**	**68.214900**	**-43.839000**	**12.178300**	1.768	2.454
Percent URM Enrollment	*-79.219200*	*42.936100*	*-17.704000*	*10.180900*	3.434	3.093
Year 2003	**-35.558100**	**5.531700**	**-7.903700**	**1.432400**	_	_
Year 2004	**-32.363100**	**5.511900**	**-8.402500**	**1.409800**	_	_
Year 2005	**-35.697000**	**5.372300**	**-11.720100**	**1.377400**	_	_
Year 2006	**-42.643100**	**5.212500**	**-13.125000**	**1.331800**	_	_
Year 2007	**-48.490200**	**4.983300**	**-12.502100**	**1.298800**	_	_
Year 2008	**-57.493900**	**4.727400**	**-13.200800**	**1.262500**	_	_
Year 2009	**-36.365100**	**4.650000**	**-10.200200**	**1.257000**	_	_
Year 2010	**-30.021900**	**4.325400**	**-6.422400**	**1.224600**	_	_
Year 2011	**-17.866400**	**4.043000**	**-3.981500**	**1.202700**	_	_
HBCU	*86.895000*	*49.998700*	*11.642200*	*17.777900*	2.611	2.812
DOCTORAL	*53.528100*	*37.298600*	**151.390000**	**10.732600**	4.778	2.446
MASTERS	*-44.062600*	*33.361900*	*2.913800*	*6.840000*	3.167	1.518
WOMEN'S COLLEGE	_	_	*4.188500*	*14.485600*	_	2.033
Intercept	*-84.051000*	*64.931200*	*-10.449700*	*12.428700*	_	_

Note: Bolded results are statistically significant at the p < .05 level.

For public institutions, time-invariant variables did not reveal significant results. However, a number of time-varying variables were related to the total degree production by institution of baccalaureate STEM degrees. Institutional characteristics found to be positively associated with total STEM degree production included expenditures for instruction and research, such that a $1,000 increase per undergraduate FTE in instructional expenditures results in an average increase of 8.5 STEM baccalaureate degrees and a $1,000 increase per FTE in research expenditures results in an average increase of .06 STEM baccalaureate degrees. In addition, percent of the undergraduate body enrolled in STEM programs, incoming student SAT average, and the size of the institution were positively related to baccalaureate STEM degree production by institution. An increase in proportion of STEM enrollment by 1% results in an average increase of 6.8 STEM baccalaureate degrees while an increase in overall undergraduate enrollment of 100 students results in an average increase of 2.9 STEM baccalaureate degrees. In addition, an increase of 1 point in average SAT score results in an average increase of .26 STEM baccalaureate degrees. Alternately, expenditures for student services and institutional support, student-to-faculty ratio, and the percentage of women represented within the undergraduate population were all negatively related to the total baccalaureate STEM degree production by institution. Expenditure findings were such that a $1,000 increase per undergraduate FTE in student services results in an average decrease of 27.2 STEM baccalaureate degrees and a $1,000 increase per undergraduate FTE in institutional expenditures results in an average decrease of 10 STEM baccalaureate degrees. In addition, an increase in student-to-faculty ratio of 1 results in an average decrease of 5.6 STEM baccalaureate degrees and an increase in the proportion of women undergraduates by one percent results in an average decrease of 2.1 STEM baccalaureate degrees overall.

For private institutions, the time-invariant variable representing doctoral institutions was significant indicating that these universities produced significantly more STEM baccalaureate degrees than other institution types, with the doctoral institution indicators averaging 10.7 more degrees. Similar to the findings for public institutions, a number of time-varying variables were found to be statistically significant in the model. Those characteristics found to be positively related to total STEM degree production included expenditures for instruction, academic support, research, and public services. Expenditures in these areas revealed that a $1,000 increase per undergraduate FTE in instructional and academic support expenditures results in an average increase of .51 and 1.2 STEM baccalaureate degrees, respectively. A $1,000 increase per FTE in research and public service expenditures results in an average increase of .03 STEM baccalaureate degrees for each expenditure type. Additionally, institution size, SAT average, and percent STEM enrollment were positively related to the outcome. An increase in proportion of STEM enrollment by 1% results in an average increase of .70 STEM baccalaureate degrees while an increase in overall undergraduate enrollment of 100 students results in an average increase of 1.2 STEM baccalaureate degrees. In addition, an increase of 1 point in average SAT score results in an average increase of .06 STEM baccalaureate degrees. Alternately, the percent of women represented in the undergraduate population was negatively related to the total number of STEM baccalaureate degrees produced such that an increase in the proportion of women undergraduates by one percent results in an average decrease of .44 STEM degrees overall.

An examination of the year effects for the 10 year period of study revealed that the total degrees produced for years 2003 through 2011 were significantly lower than the most recent year included (2012) for both public and private institutions, net the effects of institutional and year characteristics. More specifically, public institutions averaged a range of 17.9 to 48.5 fewer

STEM baccalaureate degrees in years 2003-2011 when compared to 2012. Similarly, private institutions averaged a range of 4.0 to 13.2 fewer STEM baccalaureate degrees in years 2003-2011 when compared to 2012. Figure 1 provides the average number of STEM degrees produced by public and private institutions from 2003-2012.

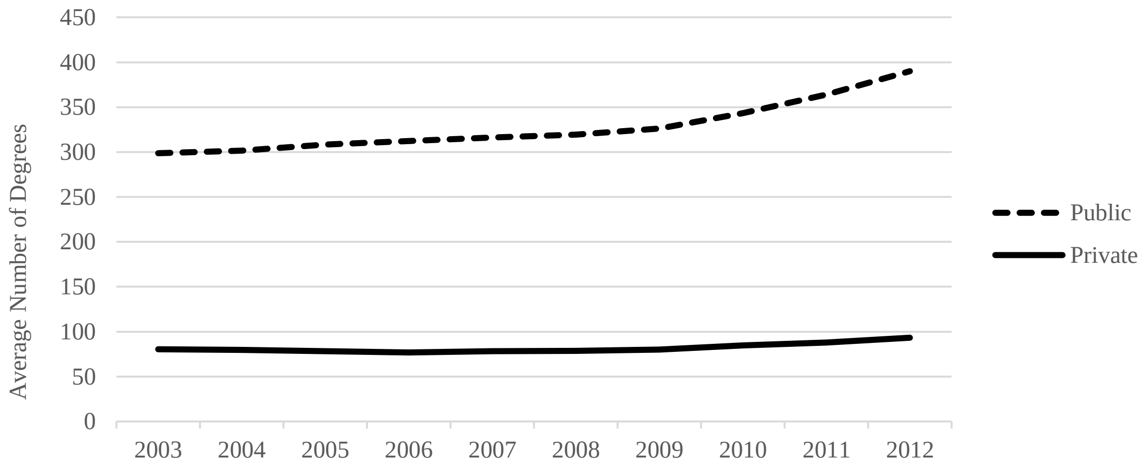

Figure 1. Average Total STEM Degrees Produced by Year by Institutional Control

The most notable difference between public and private institutions is the positive relationship of NSF funding for private institutions to total STEM baccalaureate degree production. While many of the independent variables revealed similar results for significance, the pattern of significance for expenditure variables was notably different between the public and private institutions such that more money spent on student services and institutional support in public institutions resulted in fewer STEM baccalaureate degrees being produced on average, a finding not realized in private institutions. Finally, Doctoral institutions were significantly more likely to produce a greater number of STEM baccalaureate degrees among private institutions, a finding not realized among public institutions.

NSF Funding Relationship to STEM Baccalaureate Degree Production Rate (Proportion of STEM Degrees/All Baccalaureate Degrees Awarded)

Testing of the random effects model for the rate of STEM baccalaureate degrees produced as compared to all baccalaureate degrees produced indicated there was a statistically significant relationship between total STEM degree rate production and the overall collection of independent variables in the model for public institutions (Wald $\chi^2 = 12.05$, $p < .001$) and private institutions (Wald $\chi^2 = 16.98$, $p < .001$). The variance inflation factors (VIFs) for independent variables were well below 10, indicating a reasonable level of multicollinearity for both models. Table 8 lists the results from the random effects model for total STEM degree production rate by institution, including coefficients and standard errors for each independent variable. Bolded results indicate statistically significant factors ($p < 0.05$).

The presence of an NSF award for STEM education was not significantly related to the production rate for STEM degrees in both public and private institutions. This finding indicates that the presence of NSF funding, a shift from not receiving funding to receipt of funding, does not have a significant relationship to STEM degree production rate when holding other independent variables constant. In an effort to more clearly understand the relationship of the model design to NSF award as a key independent variable, a series of four models were run for both public and private institutions to illustrate the NSF award variable's effect with the inclusion of additional variables. The Appendix contains two tables for public (Table 19) and private (Table 20) institutions with four models to predict the proportion of baccalaureate STEM degrees produced as compared to all baccalaureate degrees produced per institution. Groupings of independent variables included in the four models are as follows: NSF award only, NSF award/time-varying, NSF award/time-varying/time-invariant, and NSF award/time-varying/time-invariant/year (complete model). Findings focused on the complete model (Table 8) will be discussed below.

Table 8. Random Effects Model for Total STEM Degree Production Rate

Institutional Characteristics (IVs)	**Public Institutions**		**Private Institutions**		**VIF**	
	β	*Std. Err.*	*β*	*Std. Err.*	*Public*	*Private*
NSF Award Received	*0.000462*	*0.001182*	*0.002810*	*0.002258*	1.072	1.023
Expenditures Instruction	**0.001912**	**0.000535**	**0.000544**	**0.000169**	3.181	3.659
Expenditures Academic Support	*0.000794*	*0.000701*	*-0.000190*	*0.000447*	2.002	1.728
Expenditures Student Services	**-0.005780**	**0.002005**	**0.002074**	**0.000545**	1.326	1.962
Expenditures Institutional Support	*-0.001120*	*0.001000*	*-0.000400*	*0.000300*	1.733	2.063
Expenditures Research	*0.000004*	*0.000003*	*0.000020*	*0.000002*	3.098	2.109
Expenditures Public Services	*0.000012*	*0.000009*	**-0.000001**	**0.000009**	1.450	1.132
Size/Total Enrollment	*-0.000050*	*0.000030*	**-0.000400**	**0.000081**	2.329	1.955
Student to Faculty Ratio	*-0.000220*	*0.000280*	*-0.000180*	*0.000137*	1.492	1.280
SAT Average	*0.000001*	*0.000014*	**0.000059**	**0.000010**	2.900	2.741
Percent STEM Enrollment	**0.389800**	**0.020240**	**0.145800**	**0.011470**	2.592	1.553
Percent Women Enrollment	**-0.230700**	**0.023420**	**-0.158300**	**0.014220**	1.768	2.454
Percent URM Enrollment	*-0.004220*	*0.013880*	*-0.013640*	*0.011950*	3.434	3.093
Year 2003	**0.015310**	**0.001999**	**0.006038**	**0.001734**	_	_
Year 2004	**0.011920**	**0.001999**	**0.003850**	**0.001708**	_	_
Year 2005	**0.008439**	**0.001962**	*-0.000270*	*0.001671*	_	_
Year 2006	*0.002764*	*0.001915*	**-0.004740**	**0.001617**	_	_
Year 2007	*-0.003250*	*0.001840*	**-0.007030**	**0.001579**	_	_
Year 2008	**-0.008780**	**0.001755**	**-0.011290**	**0.001537**	_	_
Year 2009	*0.003007*	*0.001719*	**-0.007910**	**0.001531**	_	_
Year 2010	*0.001693*	*0.001611*	**-0.003610**	**0.001493**	_	_
Year 2011	*0.000790*	*0.001516*	*-0.002620*	*0.001468*	_	_
HBCU	**0.040120**	**0.014360**	**0.074650**	**0.017700**	2.611	2.812
DOCTORAL	*0.012230*	*0.010340*	**0.066170**	**0.010500**	4.778	2.446
MASTERS	*-0.006940*	*0.008932*	**-0.013170**	**0.006512**	3.167	1.518
WOMEN'S COLLEGE	_	_	**0.045930**	**0.014050**	_	2.033
Intercept	*0.222200*	*0.022060*	**0.142600**	**0.014430**	_	_

Note: Bolded results are statistically significant at the $p < .05$ level.

For public institutions, analysis of time-invariant variables revealed HBCU institutions had a significantly higher production rate indicating that HBCU institutions averaged .04 higher than non-HBCU institutions with respect to proportion of STEM degrees awarded to all baccalaureate degrees awarded. Institutional characteristics found to be positively associated with the STEM degree production rate included expenditures for instruction and the proportion of undergraduate students enrolled in STEM programs. These findings indicate that a $1,000 increase per undergraduate FTE in instruction expenditures results in an average increase of .002 with respect to the ratio of STEM baccalaureate degrees to all degrees. In addition, an increase in proportion of STEM enrollment by 1% results in an average increase of .004 with respect to the ratio of STEM baccalaureate degrees to all baccalaureate degrees. Alternately, expenditures for student services and the proportion of women enrolled in undergraduate programs were negatively related to the baccalaureate STEM degree production rate by institution. Expenditure findings were such that a $1,000 increase per undergraduate FTE in student services results in an average decrease of .002 for the STEM baccalaureate degree production rate. An increase in the proportion of women undergraduates by one percent results in an average decrease of .002 for the STEM baccalaureate degrees production rate.

For private institutions, all time-invariant variables were significant. HBCU, Women's Colleges, and doctoral institutions had significantly higher production rates for STEM degrees while Master's institutions had significantly lower production rates. HBCU's and Women's Colleges averaged a greater STEM production rate by .07 and .05, respectively. Doctoral institutions averaged a greater STEM production rate by .07, while Master's institutions averaged a lower rate at .01. A number of time-varying variables were found to be statistically significant in the model. Those characteristics found to be positively related to STEM degree production rate included expenditures for instruction and student services such that a $1,000 increase per undergraduate FTE in instructional expenditures results in an average increase of .001 in the STEM baccalaureate degree production rate and a $1,000 increase per undergraduate

FTE in student services expenditures results in an average increase of .002 in the production rate. Additionally, average SAT score and percent of STEM enrollment in the undergraduate population was positively related to the outcome. An increase in proportion of STEM enrollment by 1% results in an average increase of .15 in the STEM baccalaureate degree production rate while an increase of 1 point in average SAT score results in an average increase of .00006 in the STEM production rate. Alternately, expenditures for public services, institution size, and the percent of women represented in the undergraduate population were negatively related to the STEM degree production rate. Expenditure findings were such that a $1,000 increase per FTE in public service expenditures results in an average decrease of .000001 in the STEM baccalaureate degree production rate. In addition, an increase in undergraduate enrollment of 100 students results in an average decrease of .0004 in STEM baccalaureate degrees production rate.

An examination of the year effects for the 10 year period of study revealed that the STEM degree production rate for years 2003 through 2011 varied in pattern for public and private institutions, net the effects of institutional and year characteristics. Statistically higher production rates were seen in public institutions in early years (2003-2005) when compared to 2012, and one significantly lower effect for year 2008 when compared to 2012. The pattern for private institutions revealed a trend toward lower production rates for earlier years when compared to the 2012 production rate STEM baccalaureate degrees, however there is some variation. More specifically, public institutions averaged a range of .008 to .015 percent higher when considering STEM baccalaureate degree ratio to all degrees in years 2003-2005 when compared to 2012. This could reflect heightened interest in specific technology-related fields in the late 1990’s and early 2000’s that has not sustained over time. Private institutions revealed lower average production rates when considering the range of STEM baccalaureate degrees in more recent years (2006-2010) with a range of .002 to .008 percent less when compared to 2012. Figure 2 provides the average percent of STEM degrees to all other baccalaureate degrees produced by public and private institutions from 2003-2012.

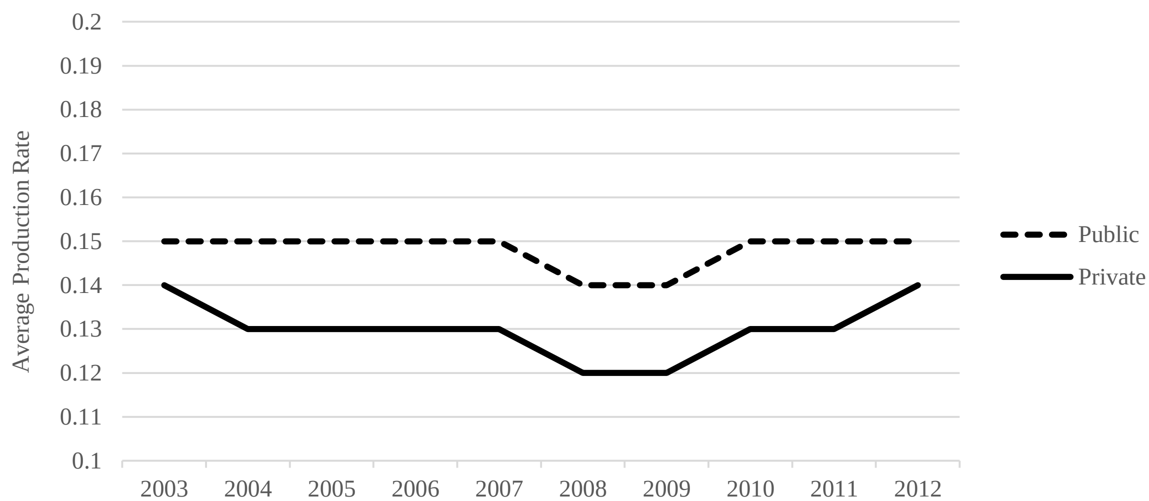

Figure 2. Average STEM Degree Production Rate by Year by Institutional Control

While many of the independent variables revealed similar results for significance with regard to STEM baccalaureate degree production rate, more model variables were significant predictors for private institutions. The most interesting difference between the public and private institutions was the significance in yearly difference for private institutions vs. public institutions with far fewer, suggesting a growth of STEM baccalaureate degree production rate within private intuitions on average over the time period, a finding not seen in public institutions.

NSF Funding Relationship to Total Baccalaureate STEM Degree Production by Women (Number of STEM Degrees Awarded to Women)

Testing of the random effects model for total STEM baccalaureate degree production for women by institution indicated there was a statistically significant relationship between total STEM degrees produced by women and the overall collection of independent variables in the model for public institutions (Wald $\chi^2 = 14.05$, $p < .001$) and private institutions (Wald $\chi^2 = 17.47$, $p < .001$). The variance inflation factors (VIFs) for independent variables were well below 10, indicating a reasonable level of multicollinearity for both models. Table 9 lists the results from the random effects model for STEM degree production for women by institution, including coefficients and standard errors for each independent variable. Bolded results indicate statistically significant factors ($p < 0.05$).

The presence of an NSF award for STEM education for women was not significantly related to the total number of STEM baccalaureate degrees produced by women for both public and private institutions. This finding indicates that the presence of NSF funding directed toward women in STEM, a shift from not receiving funding to receipt of funding, does not have a significant relationship to the total baccalaureate STEM degree production by women when holding other independent variables constant. In an effort to more clearly understand the relationship of the model design to NSF award as a key independent variable, a series of four models were run for both public and private institutions to illustrate the NSF award variable's effect with the inclusion of additional variables. The Appendix contains two tables for public (Table 21) and private (Table 22) institutions with four models to predict the total number of STEM degrees awarded to women per institution. Groupings of independent variables included in the four models are as follows: NSF award only, NSF award/time-varying, NSF award/time-varying/time-invariant, and NSF award/time-varying/time-invariant/year (complete model). Findings focused on the complete model (Table 9) will be discussed below.

Table 9. Random Effects Model for STEM Degree Production for Women

Institutional Characteristics (IVs)	Public Institutions		Private Institutions		VIF	
	β	*Std. Err.*	*β*	*Std. Err.*	*Public*	*Private*
NSF Award Received	*0.416400*	*1.887100*	*-0.273700*	*1.273700*	1.041	1.014
Expenditures Instruction	**3.198700**	**0.617800**	**0.266400**	**0.066790**	3.180	3.659
Expenditures Academic Support	*-0.890700*	*0.800800*	**0.498000**	**0.173300**	2.001	1.728
Expenditures Student Services	**-10.303000**	**2.322300**	*-0.428800*	*0.213900*	1.326	1.963
Expenditures Institutional Support	**-2.909200**	**1.145900**	*-0.149500*	*0.118900*	1.733	2.063
Expenditures Research	**0.019270**	**0.003637**	**0.017380**	**0.000872**	3.096	2.107
Expenditures Public Services	*0.018330*	*0.010040*	**0.012440**	**0.003348**	1.450	1.132
Size/Total Enrollment	**0.968300**	**0.036970**	**0.608200**	**0.028930**	2.314	1.950
Student to Faculty Ratio	**-1.802200**	**0.323000**	*0.002433*	*0.053970*	1.492	1.280
SAT Average	**0.101800**	**0.015770**	**0.034040**	**0.003776**	2.900	2.740
Percent STEM Enrollment	**248.790000**	**24.095500**	**40.406600**	**4.432900**	2.593	1.549
Percent Women Enrollment	*-27.826500*	*28.257500*	*-4.641200*	*5.282700*	1.768	2.455
Percent URM Enrollment	*-13.373300*	*17.384300*	*-8.487400*	*4.463300*	3.423	3.093
Year 2003	**-10.075000**	**2.330100**	**-5.484600**	**0.685500**	_	_
Year 2004	**-9.532900**	**2.324600**	**-5.244200**	**0.676300**	_	_
Year 2005	**-11.379700**	**2.273900**	**-6.917200**	**0.663400**	_	_
Year 2006	**-12.533600**	**2.209000**	**-6.852000**	**0.642400**	_	_
Year 2007	**-15.488700**	**2.113900**	**-7.063100**	**0.628100**	_	_
Year 2008	**-18.519800**	**2.010800**	**-7.437600**	**0.612800**	_	_
Year 2009	**-11.098200**	**1.970400**	**-5.637900**	**0.611200**	_	_
Year 2010	**-9.164700**	**1.842600**	**-3.741300**	**0.597200**	_	_
Year 2011	**-4.982400**	**1.727100**	**-2.633300**	**0.588000**	_	_
HBCU	*33.653500*	*19.192700*	**16.202100**	**5.684500**	2.610	2.808
DOCTORAL	*11.302300*	*14.094800*	**29.984000**	**3.280400**	4.778	2.446
MASTERS	*-14.155700*	*12.436200*	*-2.565800*	*1.966500*	3.167	1.516
WOMEN'S COLLEGE	_	_	**13.744600**	**4.358600**	_	2.034
Intercept	**-70.412400**	**26.639100**	**-20.513800**	**5.432300**	_	_

Note: Bolded results are statistically significant at the p < .05 level.

For public institutions, time-invariant variables did not reveal significant results. However, a number of time-varying variables were related to the total degree production by women of baccalaureate STEM degrees. Institutional characteristics found to be positively associated with total STEM degree production for women included expenditures for instruction and research, such that a $1,000 increase per undergraduate FTE in instructional expenditures results in an average increase of 3.2 STEM baccalaureate degrees by women and a $1,000 increase per FTE in research expenditures results in an average increase of .02 STEM baccalaureate degrees by women. In addition, percent of the undergraduate body enrolled in STEM programs, incoming student SAT average, and the size of the institution were positively related to baccalaureate STEM degree production for women by institution. An increase in proportion of STEM enrollment by 1% results in an average increase of 2.5 STEM baccalaureate degrees by women while an increase in overall undergraduate enrollment of 100 students results in an average increase of .97 STEM baccalaureate degrees by women. In addition, an increase of 1 point in average SAT score results in an average increase of .10 STEM baccalaureate degrees by women. Alternately, expenditures for student services and institutional support and student-to-faculty ratio were negatively related to the total baccalaureate STEM degree production for women by institution. Expenditure findings were such that a $1,000 increase per undergraduate FTE in student services results in an average decrease of 10.3 STEM baccalaureate degrees by women and a $1,000 increase per undergraduate FTE in institutional support expenditures results in an average decrease of 2.9 STEM baccalaureate degrees by women. In addition, an increase in student-to-faculty ratio of 1 results in an average decrease of 1.8 STEM baccalaureate degrees by women.

For private institutions, time-invariant variables revealed significant results. HBCU's, Women's Colleges, and doctoral institutions produced significantly more STEM baccalaureate degrees by women than other institution types. HBCU's and Women's Colleges averaged a greater number of STEM degrees produced by women at 16.2 and 13.7, respectively. Doctoral institutions averaged a greater number of STEM degrees produced by women at 30 degrees. Similar to the findings for public institutions, a number of time-varying variables were found to be statistically significant in the model. Those characteristics found to be positively related to total STEM degree production by women included expenditures for instruction, academic support, research, and public services. Expenditures in these areas revealed that a $1,000 increase per undergraduate FTE in instructional and academic support expenditures results in an average increase of .26 and .50 STEM baccalaureate degrees by women, respectively. A $1,000 increase per FTE in research and public service expenditures results in an average increase of .02 and .01 STEM baccalaureate degrees by women, respectively. Additionally, institution size, SAT average, and percent STEM enrollment were positively related to the outcome. An increase in proportion of STEM enrollment by 1% results in an average increase of .40 STEM baccalaureate degrees by women while an increase in overall undergraduate enrollment of 100 students results in an average increase of .61 STEM baccalaureate degrees by women. In addition, an increase of 1 point in average SAT score results in an average increase of .03 STEM baccalaureate degrees by women.

An examination of the year effects for the 10 year period of study revealed that the total STEM degrees produced by women for years 2003 through 2011 were significantly lower than the most recent year included (2012) for both public and private institutions, net the effects of institutional and year characteristics. More specifically, public institutions averaged a range of 5.0 to 18.5 fewer STEM baccalaureate degrees by women in years 2003-2011 when compared to 2012. Similarly, private institutions averaged a range of 2.6 to 7.4 fewer STEM baccalaureate degrees by women in years 2003-2011 when compared to 2012. Figure 3 provides the average number of STEM degrees awarded to women by public and private institutions from 2003-2012.

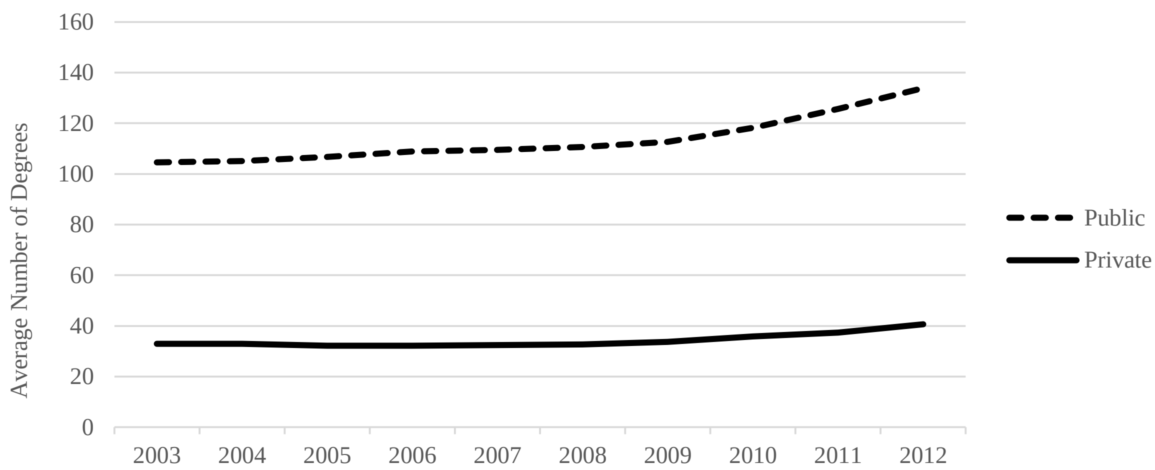

Figure 3. Average STEM Degrees Produced by Women by Year by Institutional Control

While many of the independent variables revealed similar results for significance, the pattern of significance for expenditure variables was notably different between the public and private institutions such that more money spent on student services and institutional support in public institutions resulted in significantly fewer STEM baccalaureate degrees being produced by women on average, a finding not realized in private institutions. Yearly changes in STEM baccalaureate degree production by women indicated similar patterns for public and private institutions such that there was an increase in the total number of these degrees produced over the timeframe examined. Finally, Doctoral institutions were significantly more likely to produce a greater number of STEM baccalaureate degrees among private institutions, a finding not realized among public institutions.

NSF Funding Relationship to STEM Baccalaureate Degree Production Rate for Women (Proportion of Women STEM Degrees/All STEM Baccalaureate Degrees Awarded)

Testing of the random effects model for STEM baccalaureate degree production rate for women by institution indicated there was a statistically significant relationship between STEM degrees production rate by women and the overall collection of independent variables in the model for public institutions (Wald $\chi^2 = 12.22$, $p < .001$) and private institutions (Wald $\chi^2 = 16.55$, $p < .001$). The variance inflation factors (VIFs) for independent variables were well below 10, indicating a reasonable level of multicollinearity for both models. Table 10 lists the results from the random effects model for STEM degree production rate for women by institution, including coefficients and standard errors for each independent variable. Bolded results indicate statistically significant factors ($p < 0.05$).

The presence of an NSF award for STEM education for women was not significantly related to the STEM degree production rate for women in both public and private institutions. This finding indicates that the presence of NSF funding directed toward women in STEM, a shift from not receiving funding to receipt of funding, does not have a significant relationship to the STEM degree production rate for women when holding other independent variables constant. In an effort to more clearly understand the relationship of the model design to NSF award as a key independent variable, a series of four models were run for both public and private institutions to illustrate the NSF award variable's effect with the inclusion of additional variables. The Appendix contains two tables for public (Table 23) and private (Table 24) institutions with four models to predict the proportion of baccalaureate STEM degrees produced by women as compared to all STEM baccalaureate degrees produced per institution. Groupings of independent variables included in the four models are as follows: NSF award only, NSF award/time-varying, NSF award/time-varying/time-invariant, and NSF award/time-varying/time-invariant/year (complete model). Findings focused on the complete model (Table 10) will be discussed below.

Table 10. Random Effects Model for STEM Degree Production Rate for Women

Institutional Characteristics (IVs)	Public Institutions		Private Institutions		VIF	
	β	*Std. Err.*	*β*	*Std. Err.*	*Public*	*Private*
NSF Award Received	*-0.000850*	*0.001703*	*-0.000250*	*0.003374*	1.041	1.014
Expenditures Instruction	**0.001702**	**0.000528**	**0.000524**	**0.000178**	3.180	3.663
Expenditures Academic Support	*0.000308*	*0.000712*	*-0.000460*	*0.000465*	2.001	1.725
Expenditures Student Services	**-0.004180**	**0.001956**	**0.001650**	**0.000573**	1.326	1.942
Expenditures Institutional Support	*0.000063*	*0.001003*	*-0.000380*	*0.000317*	1.733	2.060
Expenditures Research	*0.000004*	*0.000003*	**0.000020**	**0.000002**	3.096	2.110
Expenditures Public Services	*0.000006*	*0.000008*	*-0.000020*	*0.000009*	1.450	1.129
Size/Total Enrollment	**-0.000110**	**0.000026**	**-0.000460**	**0.000080**	2.314	1.950
Student to Faculty Ratio	*-0.000190*	*0.000276*	*-0.000190*	*0.000144*	1.492	1.282
SAT Average	**0.000035**	**0.000013**	**0.000054**	**0.000010**	2.900	2.754
Percent STEM Enrollment	**0.405900**	**0.018640**	**0.194700**	**0.012640**	2.593	1.581
Percent Women Enrollment	**-0.198500**	**0.020910**	**-0.161800**	**0.014790**	1.768	2.773
Percent URM Enrollment	*0.021420*	*0.011500*	*-0.018560*	*0.012140*	3.423	3.028
Year 2003	**0.015600**	**0.001951**	*0.001023*	*0.001832*	_	_
Year 2004	**0.012430**	**0.001959**	*-0.001130*	*0.001807*	_	_
Year 2005	**0.009341**	**0.001943**	**-0.004700**	**0.001770**	_	_
Year 2006	**0.006111**	**0.001908**	**-0.007400**	**0.001712**	_	_
Year 2007	*0.000803*	*0.001842*	**-0.008890**	**0.001672**	_	_
Year 2008	**-0.004800**	**0.001772**	**-0.014440**	**0.001630**	_	_
Year 2009	**0.007019**	**0.001724**	**-0.008130**	**0.001628**	_	_
Year 2010	**0.005596**	**0.001636**	**-0.004100**	**0.001589**	_	_
Year 2011	*0.002961*	*0.001555*	**-0.003820**	**0.001563**	_	_
HBCU	**0.038900**	**0.010930**	**0.088110**	**0.016270**	2.610	2.727
DOCTORAL	*-0.010640*	*0.007708*	**0.040260**	**0.009408**	4.778	2.447
MASTERS	*-0.010770*	*0.006417*	**-0.015680**	**0.005691**	3.167	1.513
WOMEN'S COLLEGE	_	_	**0.070620**	**0.012540**	_	2.273
Intercept	**0.123400**	**0.020260**	**0.131000**	**0.014830**	_	_

Note: Bolded results are statistically significant at the p < .05 level.

For public institutions, analysis of time-invariant variables revealed HBCU institutions had a significantly higher production rate, averaging .04 greater than non-HBCU. Time-varying variables were related to the production rate of STEM degrees by women as a proportion of all

STEM baccalaureate degrees awarded. Institutional characteristics found to be positively associated with the STEM degree production for women rate included expenditures for instruction, average SAT, and proportion of undergraduate students enrolled in STEM programs. The expenditure findings suggest that an increase of $1000 per undergraduate FTE in instruction expenditures results in an average increase of .0005 in the production rate of women STEM degrees when compared to all STEM baccalaureate degrees. In addition, a 1% increase in the proportion of undergraduates enrolled in STEM results in an average increase of .004 in the production rate of women STEM degrees and a 1 point increase in average SAT score results in an increase .00004 in the women STEM degree production rate. Alternately, expenditures for student services, the proportion of women enrolled in undergraduate programs, and institution size were negatively related to the baccalaureate STEM degree production rate for women by institution. Expenditure findings were such that a $1,000 increase per undergraduate FTE in student services results in an average decrease of .004 in the women STEM degree production rate. In addition, an increase in the proportion of women undergraduates by one percent results in an average decrease of .002 in women STEM degree production rate and an increase in undergraduate enrollment of 100 students results in a decrease of .0001 in women STEM degree production rate.

For private institutions, all time-invariant variables were significant. HBCU, Women's Colleges, and doctoral institutions had significantly higher production rates for STEM degrees while Master's institutions had significantly lower production rates. HBCU's and Women's Colleges averaged a greater women STEM baccalaureate degree production rate by .09 and .07, respectively. Doctoral institutions averaged a greater women STEM production rate by .04, while Master's institutions averaged a lower rate at .02. A number of time-varying variables were found to be statistically significant in the model. Those characteristics found to be positively related to STEM degree production rate included expenditures for instruction, student services, and research, such that a $1,000 increase per undergraduate FTE in instructional expenditures results in an average increase of .0005 in women STEM production rate, a $1,000 increase per undergraduate FTE in student services results in an average increase of .002 in women STEM production rate, and a $1,000 increase per FTE in research expenditures results in an average increase of .00002 in women STEM baccalaureate degree production rate. Additionally, average SAT score and percent STEM students enrolled in undergraduate programs were positively related to the outcome, such that a one point increase in average SAT results in an average increase of .00005 in the women STEM production rate and a 1% increase in the proportion of STEM undergraduates results in an average increase of .002 in the women STEM production rate. Alternately, total undergraduate enrollment and proportion of women enrolled at the undergraduate level were negatively related to the production rate of baccalaureate degrees by women in STEM. An increase in the proportion of women undergraduates by one percent results in an average decrease of .002 in women STEM baccalaureate degree production rate while an increase in the undergraduate enrollment by 100 students results in a .0005 increase in the women STEM degree production rate.

An examination of the year effects for the 10 year period of study revealed that the STEM degree production rate for women for years 2003 through 2011 varied in pattern for public and private institutions, net the effects of institutional and year characteristics. Statistically higher production rates were seen in public institutions in early years (2003-2006) and again later in the trend (2009-2010) when compared to 2012, and one significantly lower effect for year 2008 when compared to 2012. The pattern for private institutions revealed a trend toward lower production rates for earlier years when compared to the 2012 production rate for STEM baccalaureate degrees, however there is some variation. More specifically, public institutions averaged a range of .006 to .016 percent higher ratio of women STEM baccalaureate degrees to all STEM baccalaureate degrees in a majority of the years included (2003-2006, 2009-2010) when compared to 2012. Alternately, private institutions averaged a range of .004 to .014 percent lower ratio of women STEM baccalaureate degrees to all STEM baccalaureate degrees in a majority of the years included (2005-2011) when compared to 2012. Figure 4 provides the average percent of STEM degrees awarded to women to all other STEM baccalaureate degrees produced by public and private institutions from 2003-2012.

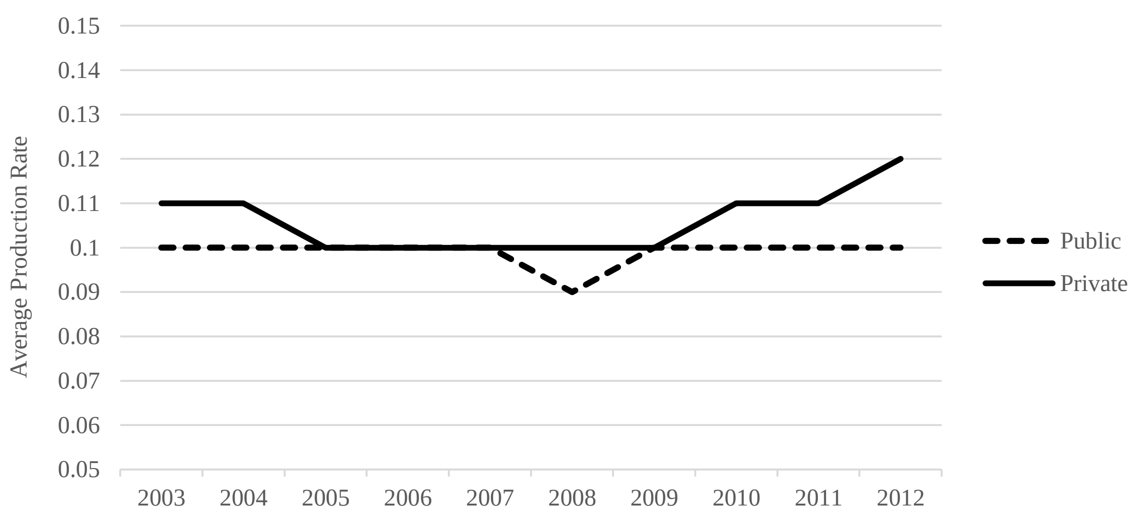

Figure 4. Average STEM Degree Production Rate for Women by Year by Institutional Control

Many of the independent variables revealed similar results for significance with regard to STEM baccalaureate degree production rate for women when comparing models for public and private institutions. A notable difference is that doctoral institutions were significantly more likely to produce a greater rate of women STEM degrees among all STEM baccalaureate degrees in private institutions while Master's institutions produced a lower rate, findings not realized among public institutions.

NSF Funding Relationship to Total Baccalaureate STEM Degree Production by URMs (Number of STEM Degrees Awarded to URMs)

Testing of the random effects model for total URM STEM baccalaureate degree production by institution indicated there was a statistically significant relationship between total STEM degrees production by URM students and the overall collection of independent variables in the model for public institutions (Wald $\chi^2 = 14.43$, $p < .001$) and private institutions (Wald $\chi^2 = 18.59$, $p < .001$). The variance inflation factors (VIFs) for independent variables were well below 10, indicating a reasonable level of multicollinearity for both models. Table 11 lists the results from the random effects model for URM STEM degree production by institution, including coefficients and standard errors for each independent variable. Bolded results indicate statistically significant factors ($p < 0.05$).

Of particular interest for the present study, the presence of an NSF award for URMs in STEM education was also positively related to the total number of STEM baccalaureate degrees produced by URMs for public institutions. This finding indicates that the presence of NSF funding, a shift from not receiving funding to receipt of funding, results in an average increase of 2.5 STEM baccalaureate degrees by URMs within the public institution. In an effort to more clearly understand the relationship of the model design to NSF award as a key independent variable, a series of four models were run for both public and private institutions to illustrate the NSF award variable's effect with the inclusion of additional variables. The Appendix contains two tables for public (Table 25) and private (Table 26) institutions with four models to predict the total number of STEM degrees awarded to URMs per institution. Groupings of independent variables included in the four models are as follows: NSF award only, NSF award/time-varying, NSF award/time-varying/time-invariant, and NSF award/time-varying/time-invariant/year (complete model). Findings focused on the complete model (Table 11) will be discussed below.

Table 11. Random Effects Model for URM STEM Degree Production

Institutional Characteristics (IVs)	**Public Institutions**		**Private Institutions**		**VIF**	
	β	*Std. Err.*	*β*	*Std. Err.*	*Public*	*Private*
NSF Award Received	**2.489700**	**1.002900**	*-0.401100*	*0.593000*	1.052	1.020
Expenditures Instruction	*-0.245100*	*0.373200*	**0.166600**	**0.033580**	3.180	3.659
Expenditures Academic Support	*0.363300*	*0.491000*	*0.020010*	*0.087750*	2.001	1.728
Expenditures Student Services	**-4.263900**	**1.395900**	*0.013130*	*0.107800*	1.326	1.962
Expenditures Institutional Support	**-2.217400**	**0.698700**	**-0.242600**	**0.059700**	1.733	2.063
Expenditures Research	**0.007847**	**0.002209**	**0.004248**	**0.000450**	3.096	2.109
Expenditures Public Services	*0.004948*	*0.005989*	**0.009200**	**0.001689**	1.450	1.132
Size/Total Enrollment	**0.512600**	**0.020460**	**0.195900**	**0.015070**	2.318	1.953
Student to Faculty Ratio	*-0.357500*	*0.194900*	*0.038340*	*0.027170*	1.492	1.280
SAT Average	**0.040270**	**0.009494**	**0.009053**	**0.001918**	2.900	2.742
Percent STEM Enrollment	**102.990000**	**13.943900**	**10.812800**	**2.247200**	2.592	1.551
Percent Women Enrollment	*-27.278100*	*16.046600*	*-4.051300*	*2.716800*	1.768	2.454
Percent URM Enrollment	**167.690000**	**9.376700**	**20.967900**	**2.291600**	3.431	3.093
Year 2003	*-2.376600*	*1.388600*	*0.034360*	*0.344300*	_	_
Year 2004	**-2.852200**	**1.390100**	*-0.153500*	*0.339500*	_	_
Year 2005	**-4.287700**	**1.368900**	*-0.618800*	*0.333000*	_	_
Year 2006	**-5.949900**	**1.336100**	**-1.188000**	**0.322100**	_	_
Year 2007	**-8.086900**	**1.284800**	**-1.109900**	**0.314800**	_	_
Year 2008	**-8.542700**	**1.227000**	**-1.539800**	**0.307000**	_	_
Year 2009	**-5.580200**	**1.199800**	**-1.292400**	**0.306000**	_	_
Year 2010	**-5.529500**	**1.127000**	**-0.948900**	**0.298800**	_	_
Year 2011	**-3.550600**	**1.063000**	**-0.821400**	**0.293900**	_	_
HBCU	**-24.354400**	**9.513800**	**26.519800**	**3.053700**	2.611	2.811
DOCTORAL	**-21.073600**	**6.815600**	**13.075900**	**1.779500**	4.778	2.446
MASTERS	**-18.066100**	**5.842900**	*1.373300*	*1.078900*	3.167	1.517
WOMEN'S COLLEGE	_	_	*1.756400*	*2.368800*	_	2.031
Intercept	**-51.153900**	**15.157100**	**-12.111400**	**2.775400**	_	_

Note: Bolded results are statistically significant at the p < .05 level.

For public institutions, time-invariant variables revealed that HBCU, doctoral, and master's institutions produced fewer STEM degrees by URM students. HBCU's averaged 24.4

fewer STEM degrees produced by URMs than non-HBCU institutions. Doctoral and master's institutions averaged fewer STEM degrees produced by URMs by 21.1 and 18.1, respectively. A number of time-varying variables were related to the total URM production of baccalaureate STEM degrees. Institutional characteristics found to be positively associated with total STEM degree production for URMs included expenditures for research, institution size, SAT average, proportion of undergraduates enrolled in STEM programs, and percent of URM enrollment. The finding for expenditures suggest that a $1,000 increase per FTE in research expenditures results in an average increase of .01 STEM baccalaureate degrees by URMs. An increase in proportion of STEM enrollment by 1% results in an average increase of 1.0 STEM baccalaureate degrees by URMs and an increase in proportion of URM enrollment by 1% results in an average increase of 1.7 STEM baccalaureate degrees by URMs. In addition, an increase in overall undergraduate enrollment of 100 students results in an average increase of .51 STEM baccalaureate degrees by URMs and a one point increase in average SAT score results in a .04 increase in STEM degrees produced by URMs. Alternately, expenditures for student services and institutional support were negatively related to the total baccalaureate STEM degree production for URMs by institution. Expenditure findings were such that a $1,000 increase per undergraduate FTE in student services results in an average decrease of 4.26 STEM baccalaureate degrees by URMs and a $1,000 increase per undergraduate FTE in institutional support expenditures results in an average decrease of 2.2 STEM baccalaureate degrees by URMs.

For private institutions, time-invariant variables revealed significant results. HBCU's and doctoral institutions produced significantly more URM STEM baccalaureate degrees than other institution types. HBCU and doctoral institutions averaged more STEM degrees produced by URMs by 26.5 and 21.1, respectively. Similar to the findings for public institutions, a number of time-varying variables were found to be statistically significant in the model. Those characteristics found to be positively related to total URM STEM degree production included expenditures for instruction, research, and public services. The finding for expenditures suggest that a $1,000 increase per undergraduate FTE in instructional expenditures results in an average increase of .17 STEM baccalaureate degrees by URMs. A $1000 increase per FTE for research and public services results in an average increase of .004 and .009 STEM degrees by URMs, respectively. Additionally, institution size, SAT average, percent STEM enrollment in the undergraduate population, and percent URM enrollment were positively related to the outcome. An increase in proportion of STEM enrollment by 1% results in an average increase of .10 STEM baccalaureate degrees by URMs and an increase in proportion of URM enrollment by 1% results in an average increase of .21 STEM baccalaureate degrees by URMs. In addition, an increase in overall undergraduate enrollment of 100 students results in an average increase of .20 STEM baccalaureate degrees by URMs and a one point increase in average SAT score results in a .01 increase in STEM degrees produced by URMs. Alternately, expenditures for institutional support were negatively related to the total baccalaureate STEM degree production for URMs by institution. Expenditure findings were such that a $1,000 increase per undergraduate FTE in institutional support expenditures results in an average decrease of .24 STEM baccalaureate degrees by URMs.

An examination of the year effects for the 10 year period of study revealed that the total STEM degrees produced by URMs for years 2003 through 2011 were generally significantly lower than the most recent year included (2012) for both public and private institutions, net the effects of institutional and year characteristics. More specifically, public institutions averaged a range 2.9 to 8.5 fewer STEM baccalaureate degrees by URMs in years 2003-2011 when compared to 2012. Private institutions averaged a range of 0.8 to 1.5 fewer STEM baccalaureate degrees by URMs in years 2006-2011 when compared to 2012, with years 2003-2005 showing a trend of non-significant average decline. Figure 5 provides the average number of STEM degrees awarded to URMs by public and private institutions from 2003-2012.

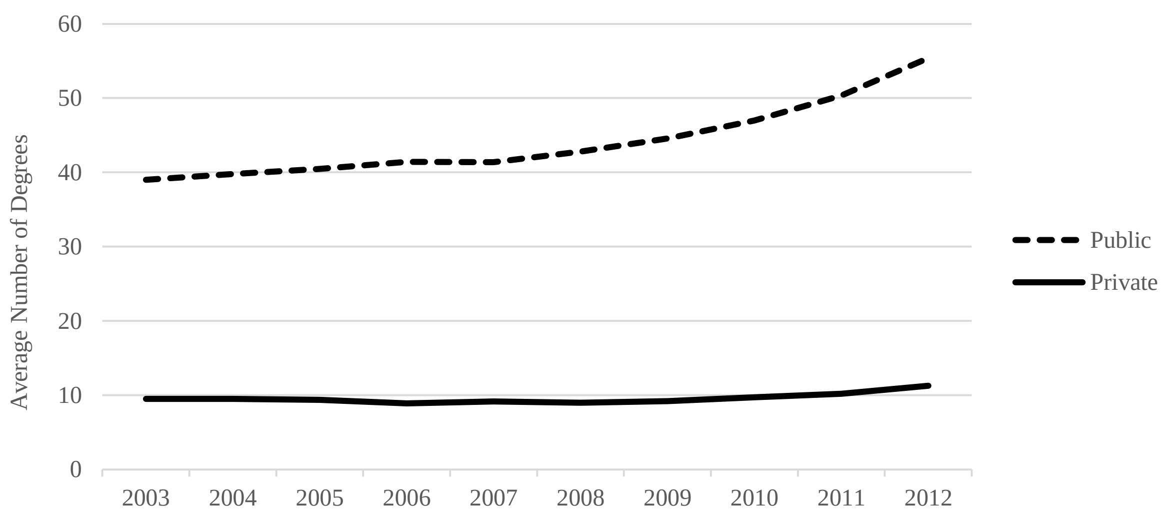

Figure 5. Average STEM Degrees Produced by URMs by Year by Institutional Control

The most notable difference between public and private institutions is the positive relationship of NSF funding for URMs for public institutions to total URM STEM baccalaureate degree production. While many of the independent variables revealed similar results for significance, the pattern of significance for expenditure variables followed other findings suggesting that an increase in student services spending at public institutions indicated an average decrease in URM STEM baccalaureate degrees produced. Doctoral institutions produced more URM STEM baccalaureate degrees in private institutions than public where baccalaureate institutions were more likely to produce URM STEM baccalaureate degrees. Finally, public institutions classified as HBCUs produced significantly fewer URM STEM baccalaureate degrees than non-HBCU institutions that were public. However, private institutions classified as HBCUs produced more URM STEM baccalaureate degrees than their non-HBCU counterparts.

NSF Funding Relationship to STEM Baccalaureate Degree Production Rate for URMs (Proportion of URM STEM Degrees/All STEM Baccalaureate Degrees Awarded)

Testing of the random effects model for URM STEM baccalaureate degree production rate by institution indicated there was a statistically significant relationship between STEM degree production rate by URM students and the overall collection of independent variables in the model for public institutions (Wald $\chi^2 = 13.04$, $p < .001$) and private institutions (Wald $\chi^2 = 14.93$, $p < .001$). The variance inflation factors (VIFs) for independent variables were well below 10, indicating a reasonable level of multicollinearity for both models. Table 12 lists the results from the random effects model for URM STEM degree production rate by institution, including coefficients and standard errors for each independent variable. Bolded results indicate statistically significant factors ($p < 0.05$).

The presence of an NSF award for STEM education for URMs was not significantly related to the STEM degree production rate for URMs in both public and private institutions. This finding indicates that the presence of NSF funding directed toward URMs in STEM, a shift from not receiving funding to receipt of funding, does not have a significant relationship to the STEM degree production rate for URMs when holding other independent variables constant. In an effort to more clearly understand the relationship of the model design to NSF award as a key independent variable, a series of four models were run for both public and private institutions to illustrate the NSF award variable's effect with the inclusion of additional variables. The Appendix contains two tables for public (Table 27) and private (Table 28) institutions with four models to predict the proportion of baccalaureate STEM degrees produced by URMs as compared to all STEM baccalaureate degrees produced per institution. Groupings of independent variables included in the four models are as follows: NSF award only, NSF award/time-varying, NSF award/time-varying/time-invariant, and NSF award/time-varying/time-invariant/year (complete model). Findings focused on the complete model (Table 12) will be discussed below.

Table 12. Random Effects Model for URM STEM Degree Production Rate

Institutional Characteristics (IVs)	**Public Institutions**		**Private Institutions**		**VIF**	
	β	*Std. Err.*	*β*	*Std. Err.*	*Public*	*Private*
NSF Award Received	*-0.001310*	*0.002865*	*0.005247*	*0.007511*	1.051	1.020
Expenditures Instruction	*0.001722*	*0.000942*	*0.000236*	*0.000381*	3.180	3.657
Expenditures Academic Support	*-0.000200*	*0.001351*	*-0.000080*	*0.000860*	2.001	1.727
Expenditures Student Services	*0.001221*	*0.003404*	*-0.000520*	*0.001155*	1.326	1.974
Expenditures Institutional Support	*-0.001480*	*0.001860*	*0.000376*	*0.000686*	1.734	2.068
Expenditures Research	*0.000009*	*0.000006*	**0.000020**	**0.000004**	3.095	2.107
Expenditures Public Services	*-0.000020*	*0.000014*	**0.000052**	**0.000018**	1.450	1.141
Size/Total Enrollment	**-0.000130**	**0.000038**	**-0.000410**	**0.000107**	2.315	1.953
Student to Faculty Ratio	*-0.000170*	*0.000498*	*0.000028*	*0.000296*	1.492	1.279
SAT Average	*0.000010*	*0.000024*	**0.000065**	**0.000019**	2.902	2.745
Percent STEM Enrollment	**0.486900**	**0.030220**	**0.444600**	**0.021880**	2.596	1.555
Percent Women Enrollment	**-0.379400**	**0.032340**	**-0.182400**	**0.022140**	1.771	2.461
Percent URM Enrollment	**0.039550**	**0.016460**	*0.000764*	*0.018550*	3.433	3.099
Year 2003	**0.024400**	**0.003583**	**0.019010**	**0.004119**	_	_
Year 2004	**0.025450**	**0.003615**	**0.020870**	**0.004086**	_	_
Year 2005	**0.014520**	**0.003628**	**0.010910**	**0.004048**	_	_
Year 2006	**0.013180**	**0.003586**	*0.001593*	*0.003944*	_	_
Year 2007	*0.002074*	*0.003485*	*-0.000570*	*0.003889*	_	_
Year 2008	*-0.000320*	*0.003378*	*-0.006810*	*0.003829*	_	_
Year 2009	**0.010920**	**0.003288**	*0.002788*	*0.003839*	_	_
Year 2010	**0.006656**	**0.003152**	*0.002959*	*0.003779*	_	_
Year 2011	*0.003730*	*0.003035*	**0.008073**	**0.003742**	_	_
HBCU	**0.036110**	**0.014590**	**0.062210**	**0.018760**	2.611	2.815
DOCTORAL	**0.001158**	**0.010200**	**0.029020**	**0.009982**	4.786	2.448
MASTERS	**0.001199**	**0.008220**	*0.003613*	*0.005533*	3.179	1.519
WOMEN'S COLLEGE	_	_	**0.073320**	**0.013320**	_	2.037
Intercept	**0.244300**	**0.033470**	**0.082050**	**0.025380**	_	_

Note: Bolded results are statistically significant at the p < .05 level.

For public institutions, analysis of time-invariant variables revealed HBCU institutions and doctoral and master's universities had significantly higher production rates. HBCU's averaged a greater URM STEM baccalaureate degree production rate by .04. Doctoral and master's institutions averaged a greater URM STEM production rate by .001 for each institution type. Time-varying variables were related to the production rate of URM STEM degrees as a proportion of all STEM baccalaureate degrees awarded. Institutional characteristics found to be positively associated with the URM STEM degree production rate included the proportion of undergraduate students enrolled in STEM programs and percent of URM students enrolled. Thus, a 1% increase in the proportion of undergraduates enrolled in STEM results in an average increase of .005 in the production rate of URM STEM degrees and a 1% increase in the proportion of URM student enrolled results in an increase of .0004 in the production rate of URM STEM degrees. Alternately, institution size and the proportion of women enrolled in undergraduate programs were negatively related to the baccalaureate STEM degree production rate for URM students by institution. An increase of 100 undergraduate students results in an average decrease of .0001 in the URM STEM degree production rate and an increase in the proportion of women undergraduates by one percent results in an average decrease of .004 in the URM STEM baccalaureate degree production rate.

For private institutions, three time-invariant variables were significant. HBCU, Women's Colleges, and doctoral institutions had significantly higher production rates for URM STEM degrees. HBCUs and Women's Colleges averaged a greater URM STEM baccalaureate degree production rate by .06 and .07, respectively. Doctoral institutions averaged a greater URM STEM production rate by .03 when compared to non-Doctoral institutions. A number of time-varying variables were found to be statistically significant in the model. Those characteristics found to be positively related to URM STEM degree production rate included expenditures for research and public services. Findings for expenditures suggest a $1,000 increase per FTE for research and public services results in an average increase in URM STEM degree production rate by .00002 and .00005, respectively. Additionally, average SAT score and percent of STEM enrollment in the undergraduate population were positively related to the outcome, such that a one point increase in average SAT results in an average increase of .00007 in the women URM STEM production rate and a 1% increase in the proportion of STEM undergraduates results in an average increase of .004 in the URM STEM production rate. Alternately, institution size and percent of women enrolled were negatively related to the URM STEM baccalaureate degree production rate. An increase in the proportion of women undergraduates by one percent results in an average decrease of .002 in URM STEM baccalaureate degree production rate while an increase in the undergraduate enrollment by 100 students results in a .0004 increase in the URM STEM degree production rate.

An examination of the year effects for the 10 year period of study revealed that the STEM degree production rate for URMs for years 2003 through 2011 varied in pattern for public and private institutions, net the effects of institutional and year characteristics. Statistically higher production rates were seen in public institutions in early years (2003-2006) and again later in the trend (2009-2010) when compared to 2012. The pattern for private institutions revealed a trend toward greater production rates for earlier years (2003-2005) when compared to the 2012 production rate for URM STEM baccalaureate degrees, however there is some variation. More specifically, public institutions averaged a range of .006 to .025 percent higher ratio of URM STEM baccalaureate degrees to all STEM baccalaureate degrees in a majority of the years included (2003-2006, 2009-2010) when compared to 2012. Private institutions revealed an averaged a range of .011 to .021 percent higher ratio of URM STEM baccalaureate degrees to all STEM baccalaureate degrees in the earlier years included in the study (2003-2005) when compared to 2012. A majority of the years for private institutions did not reveal significant year effects. Figure 6 provides the average percent of STEM degrees produced by URMs to all other baccalaureate STEM degrees produced by public and private institutions from 2003-2012.

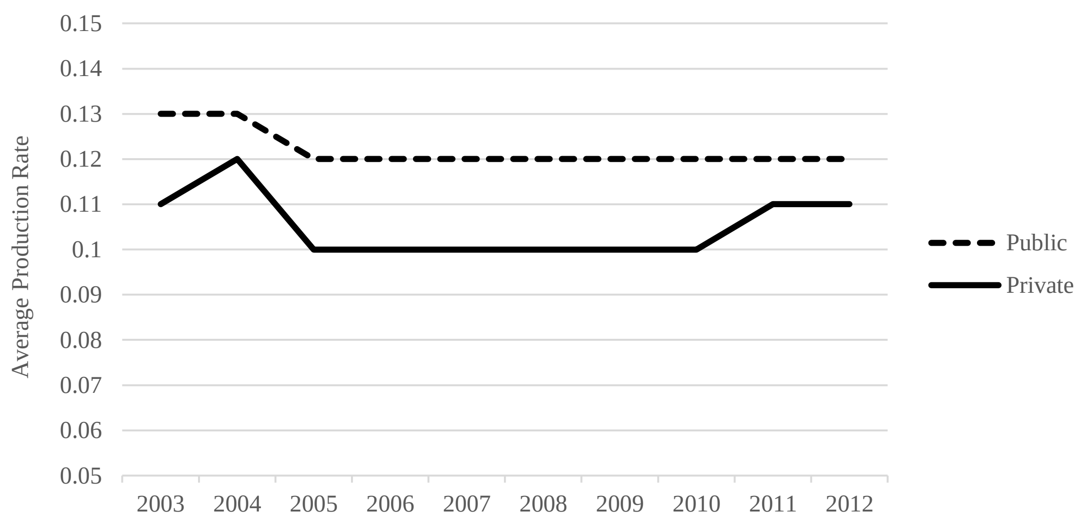

Figure 6. Average URM STEM Degree Production Rate by Year by Institutional Control

While many of the independent variables revealed similar results for significance, the pattern of significance for expenditure variables was notably different between the public and private institutions such that more money spent on research and public service in private institutions resulted in a larger proportion of URM STEM baccalaureate degree awardees among all STEM degree awardees, a finding not realized in public institutions. In addition, the proportion of URM students enrolled in an institution did have a significant positive relationship to the URM STEM degree production rate in public institutions, but this finding was not seen in the private institutions.

Summary of Random Effects Modeling Significant Independent Variables

Table 13 provides an overview of the significant findings from random effects modeling for each of the defined outcome variables. Significant institutional characteristics are included and noted as having positive or negative relationships to the outcome variable for each research question.

Table 13. Statistically Significant Findings for All Outcome Variables

Institutional Characteristics (IVs)	**Total STEM Degrees**		**STEM Prod. Rate**		**Women STEM Degrees**		**Women STEM Prod. Rate**		**URM STEM Degrees**		**URM STEM Prod. Rate**	
	Pub.	*Priv.*	*Pub.*	*Priv.*	*Pub.*	*Priv.*	*Pub.*	*Priv.*	*Pub.*	*Priv.*	*Pub.*	*Priv.*
NSF Award Received		+							+			
Expenditures Instruction	+	+	+	+	+	+	+	+		+		
Expenditures Academic Support		+				+						
Expenditures Student Services	-		-	+	-		-	+	-			
Expenditures Institutional Support	-				-				-	-		
Expenditures Research	+	+			+	+		+	+	+		+
Expenditures Public Services		+		-		+				+		+
Size/Total Enrollment	+	+		-	+	+	+	-	+	+	-	-
Student to Faculty Ratio	-				-							
SAT Average	+	+		+	+	+	+	+	+	+		+
Percent STEM Enrollment	+	+	+	+	+	+	+	+	+	+	+	+
Percent Women Enrollment	-	-	-	-			-	-			-	-
Percent URM Enrollment									+	+	+	
HBCU			+	+		+	+	+	-	+	+	+
DOCTORAL		+		+		+		+	-	+	+	+
MASTERS				-				-	-		+	
WOMEN'S COLLEGE	*		*	+	*	+	*	+	*		*	+

**Independent variable not included in model.*

Note: Results are statistically significant at the p < .05 level. The symbol '+' indicates a significant positive effect for the outcome variable, '-' indicates a significant negative effect for the outcome variable, and a blank indicates the institutional characteristic was not statistically significant for the outcome variable.

As is evident in Table 13, each outcome variable has a slightly different profile of significant findings while also revealing commonalities. The variable of particular interest, the presence of NSF funding for STEM education in general or directed toward underrepresented populations, had a positive relationship to two outcome variables. A positive relationship between NSF funding and STEM production was revealed for total STEM degrees produced in private institutions and total STEM degrees produced by URM students at public institutions.

Two variables were found to have a positive relationship to STEM degree production and production rates in total, for women and for URMs including average SAT of the incoming undergraduate student population and percent of STEM enrollment in the undergraduate population. Other time-varying variables revealed positive relationships for some dependent variables including expenditures for instruction on outcomes related to total STEM degree production and rate and STEM degree production/rate for women and expenditures for research and institution size on all three dependent outcomes related to total production. Time-invariant variables revealed higher production at private doctoral institutions for all dependent variables and a higher rate for HBCUs for many outcomes at both private and public institutions. Additionally, Women's Colleges had higher production rates for all three groups; this variable was only included in the model for private colleges.

Variables revealing a pattern of negative relationships included the percent of women enrolled in the undergraduate population for production rate of STEM in general and for underrepresented populations and institutional size for the production rate of STEM degrees by private institutions for all three related outcome categories (total, women, and URM). Expenditures for student services and institutional support at public institutions were associated with a negative relationship for STEM degrees produced at all levels in public institutions suggesting that increases in these expenditures predicted decline in production.

Due to the approach of modeling by public and private institutions separately, and the six outcome variables of interest, the consideration of individual outcomes for each model and the patterns of outcomes across models are of interest to the study.

Summary of Chapter IV

This chapter described the general pattern of the outcome variables related to overall STEM degree production and production rate, STEM degree production and production rate for women, and STEM degree production and production rate for URM students over the ten year period of study, 2003 to 2012. The results of the random effects regression models to explain the institutional patterns of growth and decline for each of the aforementioned outcome variables, by private and public institutions separately, were presented and briefly discussed. Finally, an overview of statistically significant institutional characteristics was provided to help illustrate patterns and lead into the final section of the study including discussion of the findings, limitations of the findings, and future directions for research inquiry.

CHAPTER V: DISCUSSION OF FINDINGS

As has been previously outlined, this study focused on the production of STEM baccalaureate degrees at U.S. postsecondary institutions, in total and for underrepresented ethnic minorities (URMs) and women with particular focus on federal funding for undergraduate STEM education. The reason for this emphasis was to determine if federal funding as awarded by NSF for undergraduate STEM-related efforts, produces one of the federal government's major goals for STEM in this country, production of more baccalaureate degrees in STEM fields to meet workforce needs. The goal of the study is to better understand the role of this targeted STEM funding in meeting the STEM needs of the U.S. and determining policy implications for these findings, as appropriate.

The application of random effects modeling to determine the time-varying and time-invariant institutional characteristics affecting STEM degree production outcomes provided findings to answer the research questions for this study. This chapter focuses on the major findings of the analyses and discusses their relevancy in the context of higher education policy implications. In addition, limitations of the current research study and recommendations for future research are provided.

Major Findings – NSF Award Funding for STEM Education

Ideally, the findings related to NSF funding would provide clear evidence of the relationship between this federal STEM funding source and STEM degree production. However, the outcomes relevant to this key variable do not allow for such direct interpretation and make it difficult to pronounce that NSF funding for STEM education is essential to meet the stated STEM baccalaureate degree production goals of the U.S. government. Alternatively, the varied findings by dependent variable suggest a need to know more about how STEM education funding is applied and to whom, and if financial thresholds contribute to production. The following highlights focus on the major findings for NSF funding which help shape the path for future research efforts.

One of the most important findings relative to NSF funding was the inconsistency of its effect by model. Of the twelve models run to answer each research question by institution type, two models revealed significant findings with regard to NSF award effects. For public institutions, the model focused on URM STEM degree totals revealed a positive significant relationship of the NSF award to the total number of URM students awarded STEM baccalaureate degrees. However, all other models run for public institutions revealed a lack of significance for the NSF funding variable. In private institutions, the model focused on overall STEM degree totals revealed a positive significant relationship of the NSF award to the total number of STEM baccalaureate degrees for an institution. Similar to public institutions, all other models did not reveal significant relationships for the NSF funding variable above and beyond the institutional characteristics included.

In a general sense, the presence of both significant and non-significant findings for NSF funding suggests a lack of congruence between the awarding of federal funds directed to STEM education and the goals set forth by the U.S. government to increase STEM baccalaureate degree production. This is not a surprising outcome due to previously noted reports from the Government Accountability Office suggesting a lack of coordination and accountability for federal funds focusing on STEM education and the stated need for increased organization and direction in the awarding and expected outcomes of such funding (Scott, 2012). The findings from this study provide an initial look at how directed external funding in STEM undergraduate education affects the production function to gain a better comprehension of the alignment between federal expectations and institutional performance.

Also of interest in the presented findings is the difference between overall STEM total degree production by private and public institutions. Private institutions with NSF funding experienced a significant increase in the average STEM baccalaureate degree production over time, where public institutions did not. It is important to consider how different institutions utilize the external funding and build programs based on similar NSF awards for STEM undergraduate education. In the wake of declining financial support directly to public institutions at the state level, it is possible institutional funding is redirected to cover a deficit in instructional expenditures rather than building programs that run on top of institutionally funded STEM initiatives.

Finally, outcomes suggested that directing the NSF funding to specific populations (women and URMs) is not necessarily a driver of increased production by institutions for these groups in STEM undergraduate education. While the model for public institutions revealed an average increase in STEM degree production for URM students when the institution received a URM-focused award, institutions did not increase in the proportion of URMs receiving STEM degrees when considering all STEM awardees. Private institutions did not see an increase for URM STEM degree production by NSF award for this student population. For institutions receiving STEM awards focused on women, there was no significant increase by total STEM baccalaureate degree production or rate in public and private institutions.

This is particularly interesting as it suggests the NSF awards targeting diversity initiatives do not have a significant relationship to increasing the proportion of underrepresented STEM populations within these institutions. Even when increases are seen in the total number of degrees produced (URM STEM degrees in public institutions), the proportion within the overall STEM baccalaureate awardee population is not experiencing a shift. This could indicate that NSF awards have a limited impact on programs that can reach some students, but do not reshape the focus of the institution on building capacity through diversity, another STEM goal of the U.S. government unmet.

Major findings noted in this section will be discussed in greater depth and related to the proposed conceptual framework of the study. In addition, the importance of these major findings and higher education policy implications will be addressed, with particular focus on the significance of the NSF award findings.

Findings and Conceptual Framework

The findings from this study offer support to the application of both theories included in the conceptual framework, the education production function theory (Hopkins, 1990) and the principal-agent theory as applied to higher education (Lane & Kivisto, 2008). Significant findings will be described in the context of each theory noting relevant connections to existing literature.

At its core, the education production function describes how an institutional outcome is derived from a series of inputs (Hopkins, 1990). More specifically, the inputs are defined as capital and labor and have been previously outlined for this study's specific design. The principal-agent theory supports the inclusion of the NSF award for STEM education as institutional capital with the premise that the institution, as an agent of the federal government and national goals, will apply the financial capital to the production of desired outcomes (Lane & Kivisto, 2008). Findings within the current study that NSF funding is significantly linked to increased production support the application of this theory and will be discussed in greater detail.

A number of expenditures were included in the current study's models from IPEDS data. These included research expenditures per FTE, public services expenditures per FTE, instruction expenditures per undergraduate FTE, academic support per undergraduate FTE, student services expenditures per undergraduate FTE, and institutional support expenditures per undergraduate FTE. Ryan (2004) and Webber and Ehrenberg (2010) previously found that increased expenditures in instruction, academic support and student services resulted in greater production of baccalaureate degrees. Prior research findings for expenditures for instruction by Ryan (2004) are supported by the current study where this variable indicates a significant positive effect on increased degree production for both private and public institutions in most models. Instruction expenditures were not significant for production total and rate of URM STEM degrees in public institutions or the URM production rate at private institutions. The current findings did not reveal an overwhelming pattern of significance with regard to academic support expenditures.

While models for total STEM degree production and total STEM degree production for women revealed a positive relationship for academic support expenditures, the majority of the current outcome models did not. This finding suggests that in general changes to this variable were not directly tied to the outcome of STEM degree production in total and for women. Previous findings by Webber and Ehrenberg (2010) found that higher expenditures for student services resulted in a greater number of baccalaureate degrees per institution. Interestingly, the current study reveals a varied finding for public institutions where the expenditures for student services per undergraduate FTE are negatively related to the production of STEM degrees for most outcomes with the exception of URM STEM degree production rate. Among statistically significant relationships, expenditures per FTE (or undergraduate FTE) were related positively to the degree production total or production function including research and public services.

However, the positive relationship of increased funding are not supported in all models and expenditures for institutional support and student services reveal negative relationships within some models. This finding is likely due to underlying realities of certain spending patterns. For example, an increase in spending for institutional support and student services could indicate an increase in a more ‘at-risk’ population of students academically. Patterns of funding and the underlying purposes for fluctuation are important to understanding expenditures, it is not simply a system of more funding increase production.

Institutional capital inputs were also included in the current study’s models to determine the relationship of these independent variables to the research production outcomes. These included institution size, SAT average, percent STEM enrollment, percent women enrollment, percent URM enrollment, HBCU status, Women’s college status, and institution type. Ryan (2004) previously found that increase in institution size had a positive effect on degree production rate such that an increase in enrollment results in an increase in number of degrees produced, and this is largely supported by the current findings for total STEM degree production.

However, increase in institution size revealed a significant negative relationship to production rates of STEM degrees in private institutions overall, for women, and for URMs. This finding suggests that STEM degree production rates could suffer at private institutions with an infusion of more students, possibly due to these students not enrolling in STEM programs and production proportions declining for STEM degrees. While the proportions of these populations increasing were likely to produce a positive relationship to the outcomes of the study, an anomaly was observed for STEM degree production rate of women, declining when the percent of women increases in the undergraduate population, likely because women are less inclined to enroll in STEM programs. Finally, time-invariant variables were included as inputs in the models and support previous findings by trending toward greater production of women's STEM degrees in Women's Colleges (available for private institutions only) and a greater production of URM STEM degrees in HBCUs. In general, the institutional capital findings for the current study follow the previous research outcomes for baccalaureate degree production in general and specifically within STEM fields and provide a stable model environment for inclusion of NSF funding to determine the relationship of external support targeted for STEM education in these institutions.

Labor inputs were included in the current study's models to determine how student-to-faculty ratio related to research production outcomes. Research utilizing student-to-faculty ratio as an input in baccalaureate degree production suggests a negative relationship with production outcomes (Archibald & Feldman, 2008; Scott, Bailey, & Kienzl, 2006). While the current study did not reveal many significant findings for this input, student-to-faculty ratio was negatively related to total STEM degree production and STEM degree production for women in public institutions. These findings could suggest that the opportunity for more direct contact with faculty results in successful STEM degree production, particularly in public institutions. To better understand this finding more specific institutional effort inputs for STEM production are needed in future studies.

The aforementioned financial capital, institutional capital, and labor inputs and the relationship to the current study findings focus on the primary theory guiding the framework for this study, the education production function theory. Inclusion of the NSF award funding for STEM education input applies external funding to the production model and utilizes the principal-agent model to justify inclusion of this variable into the STEM degree production models in the current study. While previous studies were not directly related to a federal grant funding process as a source of principal support to the desired agent's outcome, two studies focused on state-level policy and degree production provide a related source (Titus, 2009a; Titus, 2009b). In both studies, the provision of state aid with an understanding of degree production as part of the successful outcome for the institutions, resulted in increased production, particularly for low producing institutions. The significant findings for NSF award funding for STEM education from the current study are supported by these previous findings with the inclusion of the NSF award for STEM education resulting in increased total STEM degree production for private institutions and increased total STEM degree production for URM students at public institutions. These early findings suggest a need for future research endeavors to better understand the relationship of institution control with these two defined production outcomes.

Overall, the findings from the twelve random effects models conducted are supported by previous research focused on baccalaureate degree production in general and for STEM degrees specifically. While there certainly was variation among models for all STEM degrees and for underrepresented populations, as well as by institutional control, the general patterns of the education production function applied to STEM baccalaureate degree production hold. The application of an external funding variable focused on STEM education utilizing the principal-agent theory had varied results and suggests that future research in this area could prove useful to understanding this variation. Policy implications and future directions for research will be considered in detail in the remainder of this chapter.

Policy Implications

The findings from the current study (along with supporting literature for degree production outcomes in STEM) signal a varied pattern of significant outcomes for STEM degree production, particularly as it relates to external NSF grant funding for STEM education. These findings support the need for outlined goals and structured coordination of STEM-focused education awards to ensure that financial support for STEM programs at institutions result in the desired outcomes, as has been previously proposed (Ashby, 2006; Gonzalez & Kuenzi, 2012; Scott, 2012).

The need for increased coordination of goals and related outcomes to determine if the targeted federal funding is being applied in a manner that supports federal goals of increased STEM degree production is supported by finding some significant results for specific outcomes, but not revealing a significant impact across the landscape of outcome variables. There is also need to better capture the relationship of NSF federal funding to determine if it is being applied effectively for desired outcomes or misappropriated to less successful STEM programs. Longitudinal modeling with random effects allows for both time-varying and time-invariant analysis to determine those institutional characteristics that can be changed over time and those that cannot, but may provide insight into approaches at various levels including program, institutional, state, and national levels. This section will outline policy implications and the institution and national levels.

Policy Implications for Institutions

Institution-specific degree production outcomes are the focus of the analysis conducted in this study through random effects modeling. A benefit of applying panel analysis to STEM degree production data is the ability to determine what inputs reveal positive or negative effects on production and production rates within institutions over time allowing for change across time to serve as the effect and provide actionable results for future application (Zhang, 2010). Findings suggest that increased expenditures in specific areas of the institution resulted in increased degree production for at least one of the outcome areas. Of particular note, an increase in the expenditures per undergraduate FTE for instruction at the institutional level resulted in increased production of overall STEM degrees and STEM degrees for women at both public and private institutions. However, this pattern was not the same for URM STEM degree production. This finding could indicate that there is an opportunity for institutions to direct funding for instruction to URM STEM programs.

Expenditures for student services per undergraduate student FTE had a slightly different result for public institutions where a decline in dollars spent on these services resulted in a greater number of STEM degrees produced at public institutions. Due to the nature of public institutions generally serving a wider body of academically prepared students, an increase in student services may suggest a greater focus on general education preparation and remediation and less funding available for supporting specific programs such as STEM. In addition, expenditures for research per FTE may indicate that institutions seeking funding for research endeavors attract and produce more undergraduate STEM enrollments and baccalaureate degrees in the progress. This finding holds true for total degrees produced for all STEM and the underrepresented populations, but does not increase the STEM production rate, another approach needed to lift the number of STEM degrees to nationally desired goal levels (President's Council of Education and the Workforce, 2010).

Unsurprisingly, institutions with increasing total enrollment and proportion of STEM students in the undergraduate population produced a greater number of STEM baccalaureate degrees for all of the groups noted. While this is also an obvious strategy at the institutional level, it is one that has been noted on a larger scale (American Institutes for Research, 2012; Center on Education and the Workforce, 2010; President's Council of Advisors on Science and Technology, 2012). While time-varying input variables were found to be significant predictors of upward trends in STEM degree production overall, for women, and for URM students, the ability of institutions to make similar changes in a shorter timeframe, or at all, is in question. This could be due, in part, to the desire for institutional financial resources to be placed toward a multitude of efforts and purposes that might not be directly or tangentially related to the STEM education and degree production needs of the nation. These institutional implications lead into national implications for policy development to supplement and support institution-level efforts in STEM baccalaureate degree production when institutional resources are not great enough to support this goal alone.

Policy Implications for Federal Funding Initiatives

Inclusion of the NSF award funding for STEM education variables for all STEM programs and for those targeted to underrepresented groups in STEM provided findings for the application of Federal funding as a principal of institutional agency in the form of STEM baccalaureate degree production. Considering this input variable among other, more institution-specific inputs, allowed for application of the principal-agent theory within the education production function to determine if the NSF funding acts as a proxy for the national goal of increased STEM baccalaureate degree attainment (Hopkins, 1990; Lane & Kivisto, 2008).

Within the current study, NSF award funding for overall STEM education programming was found to be significant for the total STEM degree production function in private institutions. The presence of this finding suggests that targeted funding from federal sources could produce the desired outcome of increased STEM baccalaureate degree production to meet current and future U.S. workforce needs, but presence alone is not enough to ensure these goals are met. While NSF funding may serve to support institutions in producing more STEM education opportunities and increase STEM baccalaureate degree production, it is obviously not the only result of NSF funding within these institutions. If the production of more STEM degrees is the key goal of national efforts around postsecondary institutions, this outcome should be clearly linked to funding opportunities for these institutions.

A review of all twelve models of STEM baccalaureate degree production outcomes revealed the only other model proving NSF award funding to be significant was that of total URM STEM degree production at public institutions. This finding is particularly important for national policy as it feeds directly into the report from the President's Council of Education and the Workforce (2010) outlining the need for increased diversity of STEM baccalaureate degree recipients. Evidence that NSF funding directed toward URM STEM education increases URM STEM baccalaureate degree production by institution provides a foundation for further study of these programs and the possibility of increased funding of such programs for more institutions to benefit from directed STEM education efforts.

A major focus for policy implications within this study was the ability to apply external, directed funding for STEM education to the production of more STEM baccalaureate degrees by increasing numbers or proportions, a focus of numerous reports at the national level in recent years (American Institutes for Research, 2012; Center on Education and the Workforce, 2010; President's Council of Advisors on Science and Technology, 2012). While additional accountability for federal funding outcomes related to STEM awards could be key to better assessing the relationship of these inputs, additional research is needed to fully understand the impact of NSF awards for institutions related to STEM education initiatives. The following section will focus on the limitations of the current study and future research opportunities related STEM baccalaureate degree production.

Future Directions for Research

As with any study, the current research approach has limitations of data, analysis, and application. Application of the data to a statistical model for analysis required selection of one model to best describe the variable needed for the education production function. Due to the presence of both time-varying and time-invariant inputs, the random effects model was deemed the best approach for the data at hand as it allowed for the model to hold constant all factors already determined to be factors in baccalaureate degree production regardless of variable type. In addition, the statistical procedures utilized lend to policy implications for within-institution application. While findings for time-invariant variables in the random effects model did explain differences between institution types, these are not changeable variables and thus do not lend to policy implications for reasonable within-institution change.

The approach to the inclusion of the NSF variable presented limitations for analysis and interpretation. The current study focused on the receipt of NSF award funding as a measure of input to the production function. The application of a dichotomous NSF award variable to the model, however, does not allow the study to examine possible differential effects by amount of funding or specific program interventions. Future research should examine the role of the amount of funding and the type of intervention to determine how they influence the dependent variables.

The goal of how NSF funding relates to STEM degree production within an institution focused the analyses on changes over time within the institution and less on the differences between types of institutions. This was due primarily to the nature of NSF funding being applied at the individual institutional level rather than at greater demographic categories. Based on this approach, those variables that can be altered across time within the institution, particularly the variable of interest related to NSF award funding for STEM education, were discussed.

Additionally, the study focused on specific definitions of degree production including baccalaureate STEM degree totals and production rate of STEM baccalaureate as ratio of STEM degrees to all degrees awarded. This approach allows for a consistent and reasonable set of dependent variables for modeling. Nevertheless, there can be other types of STEM degree production that is worth examining in future research. For example, URM STEM production rate could be measured for the underrepresented populations as the proportion of URM baccalaureate degrees awarded for a slightly different outcome measure. This focus on growth/decline of STEM in URM student populations as opposed to growth/decline of URM in STEM populations could be an area of future research.

The current study has a number of opportunities for future research approaches and additional findings to provide supporting details for the outline findings. The NSF award for STEM education is a variable that was included in the current study as being present within an institution for a particular year and amount or number of NSF awards by institution was not considered. Additional information on these awards, including total amount received per undergraduate FTE and number of awards per year per institution, would allow for more detailed knowledge of the significant findings in the current study related to NSF funding and as an extension of current findings to determine if number of awards or amount received produce additional significant findings for other dependent outcomes of interest. Additionally, some of the time-invariant variables revealed interesting findings including doctoral private institutions producing greater numbers of STEM baccalaureate degrees for all three groups of interest. Understanding the differences between institution types, specifically with regard to women and URM baccalaureate degree production in STEM programs, could provide strategies to be applied more widely. In general, additional research is needed to help explain how institutions find success in STEM degree production and determine the applicability to other institutions.

Conclusion

This study considered the production totals and rates for STEM baccalaureate degrees by institution in U.S. postsecondary institutions, an area of focus at the national level for workforce development and international competition. More specifically, the study served to better understand how the education production function intermeshed with the principal-agent theory to determine the relationship of external funding for STEM education to degree production totals and rates overall, for women and for URMs. A variety of institutional variables were applied to provide an appropriate base of inputs for the outcome variables including expenditure, institution size, demographic proportions, SAT average, and student-to-faculty ratio. In addition to these time-varying variables, time-invariant variables related to HBCU status, Women's College status, and instruction type were included. The application of a random effects model for each research question by institution control allowed for significant findings of time-varying and time-invariant inputs.

NSF award funding, the input variable of particular interest, proved to be significant in two of twelve models including total STEM degree production for private institutions and total URM STEM degree production for public institutions. While few private institutions over the period of measurement received NSF funding for STEM undergraduate education, the significance of this funding could indicate that there is a perception that public institutions need the funding to be effective, when the findings point to private institutions as more effectively utilizing funding to produce a greater number of STEM baccalaureate degrees. Alternately, the increase and notably larger proportion of public institutions receiving NSF funding for URM

STEM undergraduate education could be an indicator of multiple sources of expectation in lift of STEM degree production for public institutions (including community and state pressures) to meet workforce needs with increased diversity representing the local populations.

Ultimately, the presence of both significant and nonsignificant findings for the NSF awards may indicate that there are ways in which these funds affect production and continued research efforts along these lines would be advisable. Policy implications include a proposal to better define outcomes and assessment for external funding and ensure that targeted federal dollars align with production of desired outcomes. In addition, institutions may find that not just increasing total enrollment but increasing the proportion of STEM enrollment in the undergraduate population provides greater production of both STEM degree totals and production rates for all groups of interest.

In conclusion, the application of external funding directed toward national outcomes of interest for higher education yielded varied outcomes and resulted in more questions asked than answered. The current findings serve as a blueprint to study the NSF funding variable in greater depth, expand the definition of external funding for STEM at the institution level, and learn more about how institutions build a culture of STEM and diversity in STEM undergraduate education. The relationship between the U.S. government and postsecondary institutions will be key to developing a globally competitive STEM workforce; understanding how that relationship works best an essential next step.

CHAPTER VI: APPENDIX

Table 14: List of STEM Fields and Associated 2000 CIP Codes

CIP code	**CIP title for STEM Program**
11.0101	Computer and Information Sciences, General.
11.0102	Artificial Intelligence and Robotics.
11.0103	Information Technology.
11.0201	Computer Programming/Programmer, General.
11.0202	Computer Programming, Specific Applications.
11.0203	Computer Programming, Vendor/Product Certification.
11.0301	Data Processing and Data Processing Technology/Technician.
11.0401	Information Science/Studies.
11.0501	Computer Systems Analysis/Analyst.
11.0701	Computer Science.
11.0801	Web Page, Digital/Multimedia and Information Resources Design.
11.0802	Data Modeling/Warehousing and Database Administration.
11.0803	Computer Graphics.
11.0901	Computer Systems Networking and Telecommunications.
11.1001	System Administration/Administrator.
11.1002	System, Networking, and LAN/WAN Management/Manager.
11.1003	Computer and Information Systems Security.
11.1004	Web/Multimedia Management and Webmaster.
14.0101	Engineering, General.
14.0201	Aerospace, Aeronautical and Astronautical Engineering.
14.0301	Agricultural/Biological Engineering and Bioengineering.
14.0401	Architectural Engineering.
14.0501	Biomedical/Medical Engineering.
14.0601	Ceramic Sciences and Engineering.
14.0701	Chemical Engineering
14.0801	Civil Engineering, General.
14.0802	Geotechnical Engineering.
14.0803	Structural Engineering.
14.0804	Transportation and Highway Engineering.
14.0805	Water Resources Engineering.
14.0901	Computer Engineering, General.
14.0902	Computer Hardware Engineering.
14.0903	Computer Software Engineering.
14.1001	Electrical, Electronics and Communications Engineering.
14.1101	Engineering Mechanics.
14.1201	Engineering Physics.
14.1301	Engineering Science.
14.1401	Environmental/Environmental Health Engineering.
14.1801	Materials Engineering.
14.1901	Mechanical Engineering.
14.2001	Metallurgical Engineering.
14.2101	Mining and Mineral Engineering.
14.2201	Naval Architecture and Marine Engineering.
14.2301	Nuclear Engineering.
14.2401	Ocean Engineering.
14.2501	Petroleum Engineering.
14.2701	Systems Engineering.

14.2801	Textile Sciences and Engineering.
14.3101	Materials Science.
14.3201	Polymer/Plastics Engineering.
14.3301	Construction Engineering.
14.3401	Forest Engineering.
14.3501	Industrial Engineering.
14.3601	Manufacturing Engineering.
14.3701	Operations Research.
14.3801	Surveying Engineering.
14.3901	Geological/Geophysical Engineering.
15.0000	Engineering Technology, General.
15.0101	Architectural Engineering Technology/Technician.
15.0201	Civil Engineering Technology/Technician.
15.0303	Electrical, Electronic and Communications Engineering Technology/Technician.
15.0304	Laser and Optical Technology/Technician.
15.0305	Telecommunications Technology/Technician.
15.0401	Biomedical Technology/Technician.
15.0403	Electromechanical Technology/Electromechanical Engineering Technology.
15.0404	Instrumentation Technology/Technician.
15.0405	Robotics Technology/Technician.
15.0501	Heating, Air Conditioning and Refrigeration Technology/Technician (ACH/ACR/ACHR/HRAC/HVAC/AC Technology).
15.0503	Energy Management and Systems Technology/Technician.
15.0505	Solar Energy Technology/Technician.
15.0506	Water Quality and Wastewater Treatment Management and Recycling Technology/Technician.
15.0507	Environmental Engineering Technology/Environmental Technology.
15.0508	Hazardous Materials Management and Waste Technology/Technician.
15.0607	Plastics Engineering Technology/Technician.
15.0611	Metallurgical Technology/Technician.
15.0612	Industrial Technology/Technician.
15.0613	Manufacturing Technology/Technician.
15.0701	Occupational Safety and Health Technology/Technician.
15.0702	Quality Control Technology/Technician.
15.0703	Industrial Safety Technology/Technician.
15.0704	Hazardous Materials Information Systems Technology/Technician.
15.0801	Aeronautical/Aerospace Engineering Technology/Technician.
15.0803	Automotive Engineering Technology/Technician.
15.0805	Mechanical Engineering/Mechanical Technology/Technician.
15.0901	Mining Technology/Technician.
15.0903	Petroleum Technology/Technician.
15.1001	Construction Engineering Technology/Technician.
15.1102	Surveying Technology/Surveying.
15.1103	Hydraulics and Fluid Power Technology/Technician.
15.1201	Computer Engineering Technology/Technician.
15.1202	Computer Technology/Computer Systems Technology.
15.1203	Computer Hardware Technology/Technician.
15.1204	Computer Software Technology/Technician.
15.1301	Drafting and Design Technology/Technician, General.
15.1302	CAD/CADD Drafting and/or Design Technology/Technician.
15.1303	Architectural Drafting and Architectural CAD/CADD.
15.1304	Civil Drafting and Civil Engineering CAD/CADD.
15.1305	Electrical/Electronics Drafting and Electrical/Electronics CAD/CADD.
15.1306	Mechanical Drafting and Mechanical Drafting CAD/CADD.
15.1401	Nuclear Engineering Technology/Technician.

15.1501	Engineering/Industrial Management.
26.0101	Biology/Biological Sciences, General.
26.0102	Biomedical Sciences, General.
26.0202	Biochemistry.
26.0203	Biophysics.
26.0204	Molecular Biology.
26.0205	Molecular Biochemistry.
26.0206	Molecular Biophysics.
26.0207	Structural Biology.
26.0208	Photobiology.
26.0209	Radiation Biology/Radiobiology.
26.0210	Biochemistry/Biophysics and Molecular Biology.
26.0301	Botany/Plant Biology.
26.0305	Plant Pathology/Phytopathology.
26.0307	Plant Physiology.
26.0308	Plant Molecular Biology.
26.0401	Cell/Cellular Biology and Histology.
26.0403	Anatomy.
26.0404	Developmental Biology and Embryology.
26.0405	Neuroanatomy.
26.0406	Cell/Cellular and Molecular Biology.
26.0407	Cell Biology and Anatomy.
26.0502	Microbiology, General.
26.0503	Medical Microbiology and Bacteriology.
26.0504	Virology.
26.0505	Parasitology.
26.0506	Mycology.
26.0507	Immunology.
26.0701	Zoology/Animal Biology.
26.0702	Entomology.
26.0707	Animal Physiology.
26.0708	Animal Behavior and Ethology.
26.0709	Wildlife Biology.
26.0801	Genetics, General.
26.0802	Molecular Genetics.
26.0803	Microbial and Eukaryotic Genetics.
26.0804	Animal Genetics.
26.0805	Plant Genetics.
26.0806	Human/Medical Genetics.
26.0901	Physiology, General.
26.0902	Molecular Physiology.
26.0903	Cell Physiology.
26.0904	Endocrinology.
26.0905	Reproductive Biology.
26.0906	Neurobiology and Neurophysiology.
26.0907	Cardiovascular Science.
26.0908	Exercise Physiology.
26.0909	Vision Science/Physiological Optics.
26.0910	Pathology/Experimental Pathology.
26.0911	Oncology and Cancer Biology.
26.1001	Pharmacology.
26.1002	Molecular Pharmacology.
26.1003	Neuropharmacology.
26.1004	Toxicology.

26.1005 Molecular Toxicology.
26.1006 Environmental Toxicology.
26.1007 Pharmacology and Toxicology.
26.1101 Biometry/Biometrics.
26.1102 Biostatistics.
26.1103 Bioinformatics.
26.1201 Biotechnology.
26.1301 Ecology.
26.1302 Marine Biology and Biological Oceanography.
26.1303 Evolutionary Biology.
26.1304 Aquatic Biology/Limnology.
26.1305 Environmental Biology.
26.1306 Population Biology.
26.1307 Conservation Biology.
26.1308 Systematic Biology/Biological Systematics.
26.1309 Epidemiology.
27.0101 Mathematics, General.
27.0102 Algebra and Number Theory.
27.0103 Analysis and Functional Analysis.
27.0104 Geometry/Geometric Analysis.
27.0105 Topology and Foundations.
27.0301 Applied Mathematics.
27.0303 Computational Mathematics.
27.0501 Statistics, General.
27.0502 Mathematical Statistics and Probability.
52.1304 Actuarial Science.
40.0101 Physical Sciences.
40.0201 Astronomy.
40.0202 Astrophysics.
40.0203 Planetary Astronomy and Science.
40.0401 Atmospheric Sciences and Meteorology, General.
40.0402 Atmospheric Chemistry and Climatology.
40.0403 Atmospheric Physics and Dynamics.
40.0404 Meteorology.
40.0501 Chemistry, General.
40.0502 Analytical Chemistry.
40.0503 Inorganic Chemistry.
40.0504 Organic Chemistry.
40.0506 Physical and Theoretical Chemistry.
40.0507 Polymer Chemistry.
40.0508 Chemical Physics.
40.0601 Geology/Earth Science, General.
40.0602 Geochemistry.
40.0603 Geophysics and Seismology.
40.0604 Paleontology.
40.0605 Hydrology and Water Resources Science.
40.0606 Geochemistry and Petrology.
40.0607 Oceanography, Chemical and Physical.
40.0801 Physics, General.
40.0802 Atomic/Molecular Physics.
40.0804 Elementary Particle Physics.
40.0805 Plasma and High-Temperature Physics.
40.0806 Nuclear Physics.
40.0807 Optics/Optical Sciences.

Table 15

Descriptive Statistics for Independent Variables - Public Institutions

	2003				2004				2005				2006				2007			
	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
NSF Award Received (General)	0.09	0.29	0.00	1.00	0.09	0.29	0.00	1.00	0.11	0.31	0.00	1.00	0.11	0.32	0.00	1.00	0.07	0.26	0.00	1.00
NSF Award Received (Women)	0.04	0.19	0.00	1.00	0.04	0.21	0.00	1.00	0.03	0.18	0.00	1.00	0.05	0.22	0.00	1.00	0.04	0.20	0.00	1.00
NSF Award Received (URM)	0.06	0.24	0.00	1.00	0.06	0.24	0.00	1.00	0.04	0.19	0.00	1.00	0.06	0.24	0.00	1.00	0.04	0.21	0.00	1.00
Expenditures Instruction	5.85	3.03	0.00	25.61	5.55	2.08	0.00	18.98	5.65	2.08	0.72	18.78	5.66	2.06	0.99	19.50	5.72	2.12	0.00	19.37
Expenditures Academic Support	1.55	1.09	0.00	9.31	1.49	0.84	0.17	7.47	1.39	0.77	0.18	6.00	1.38	0.76	0.18	6.02	1.41	0.78	0.20	6.15
Expenditures Student Services	1.04	0.53	0.25	6.60	1.02	0.45	0.25	3.26	1.05	0.47	0.27	3.33	1.04	0.46	0.28	2.98	1.06	0.47	0.28	3.21
Expenditures Institutional Support	1.67	0.96	0.00	8.77	1.61	0.83	0.37	7.02	1.62	0.78	0.37	6.21	1.65	0.81	0.32	6.87	1.67	0.83	0.34	6.63
Expenditures Research	151.51	279.10	0.00	2016.52	166.97	312.54	0.00	2323.25	184.19	323.83	0.00	1944.57	188.70	328.85	0.00	2126.32	185.08	355.24	0.00	3292.56
Expenditures Public Services	82.88	127.46	0.00	1584.06	90.48	135.82	0.00	1681.24	92.74	126.91	0.00	1328.54	93.40	127.22	0.00	1301.86	91.22	136.82	0.00	1372.14
Size/Total Enrollment	96.80	75.80	6.36	374.80	97.54	76.06	6.25	381.17	98.85	77.46	5.78	396.49	100.07	78.88	5.49	392.57	101.60	80.32	5.54	409.83
Student to Faculty Ratio	16.57	3.61	0.00	37.09	16.52	3.41	6.77	27.26	16.44	3.43	4.86	31.70	16.18	3.21	5.29	30.67	15.99	3.14	5.60	27.20
SAT Average	1035.83	101.22	790.00	1350.00	1040.99	101.07	797.00	1345.00	1045.55	101.90	760.00	1350.00	1040.70	102.67	805.00	1340.00	1034.21	104.75	745.00	1350.00
Percent STEM Enrollment	0.12	0.09	0.00	0.71	0.12	0.09	0.00	0.71	0.12	0.09	0.00	0.67	0.13	0.09	0.00	0.80	0.14	0.09	0.00	0.88
Percent Women Enrollment	0.57	0.08	0.06	0.95	0.56	0.08	0.06	0.94	0.56	0.08	0.06	0.93	0.56	0.08	0.06	0.93	0.56	0.08	0.07	0.93
Percent URM Enrollment	0.22	0.24	0.01	0.98	0.22	0.24	0.02	0.98	0.23	0.24	0.01	0.98	0.23	0.24	0.01	0.98	0.23	0.24	0.02	0.98
HBCU	0.08	0.27	0.00	1.00	0.08	0.27	0.00	1.00	0.08	0.27	0.00	1.00	0.08	0.27	0.00	1.00	0.08	0.27	0.00	1.00
DOCTORAL	0.34	0.48	0.00	1.00	0.34	0.48	0.00	1.00	0.34	0.48	0.00	1.00	0.34	0.48	0.00	1.00	0.34	0.48	0.00	1.00
MASTERS	0.52	0.50	0.00	1.00	0.52	0.50	0.00	1.00	0.52	0.50	0.00	1.00	0.52	0.50	0.00	1.00	0.52	0.50	0.00	1.00
BACHELORS	0.13	0.34	0.00	1.00	0.13	0.34	0.00	1.00	0.13	0.34	0.00	1.00	0.13	0.34	0.00	1.00	0.13	0.34	0.00	1.00

Cont

	2008				2009				2010				2011				2012			
	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
NSF Award Received (General)	0.11	0.31	0.00	1.00	0.03	0.17	0.00	1.00	0.13	0.33	0.00	1.00	0.16	0.37	0.00	1.00	0.17	0.37	0.00	1.00
NSF Award Received (Women)	0.06	0.24	0.00	1.00	0.01	0.12	0.00	1.00	0.05	0.23	0.00	1.00	0.08	0.27	0.00	1.00	0.08	0.27	0.00	1.00
NSF Award Received (URM)	0.08	0.28	0.00	1.00	0.02	0.13	0.00	1.00	0.09	0.29	0.00	1.00	0.11	0.32	0.00	1.00	0.11	0.32	0.00	1.00
Expenditures Instruction	5.97	2.35	0.00	21.03	6.27	2.42	0.00	21.66	6.60	2.57	0.00	22.87	7.16	2.73	0.00	25.02	7.42	2.93	0.00	25.97
Expenditures Academic Support	1.49	0.81	0.20	6.26	1.58	0.87	0.18	6.42	1.66	0.94	0.17	7.92	1.86	1.47	0.17	25.79	1.95	1.58	0.19	27.58
Expenditures Student Services	1.12	0.50	0.27	3.57	1.18	0.53	0.27	3.83	1.25	0.55	0.33	4.27	1.38	0.62	0.41	5.14	1.44	0.63	0.41	4.78
Expenditures Institutional Support	1.72	0.77	0.28	5.87	1.82	0.85	0.40	7.14	1.94	0.89	0.46	6.49	2.15	0.99	0.55	8.92	2.21	1.05	0.52	8.26
Expenditures Research	196.67	365.37	0.00	2849.01	200.55	364.41	0.00	2329.16	212.15	432.56	0.00	5560.27	225.35	453.32	0.00	5613.79	237.46	486.24	0.00	6107.55
Expenditures Public Services	93.86	132.08	0.00	1370.78	97.42	136.05	0.00	1494.34	99.84	145.59	0.00	1623.87	106.25	153.56	0.00	1852.64	109.12	165.34	0.00	2108.61
Size/Total Enrollment	103.46	82.81	0.11	528.83	106.32	83.96	5.74	539.02	108.38	85.10	5.89	562.32	110.33	87.24	5.97	581.84	110.73	88.66	6.27	591.83
Student to Faculty Ratio	15.95	3.17	5.37	26.84	16.53	3.33	5.88	29.19	16.69	3.37	6.78	29.77	16.72	3.47	6.18	29.97	16.54	3.67	6.88	35.94
SAT Average	1035.63	107.93	755.00	1345.00	1036.48	108.52	755.00	1345.00	1039.71	107.37	755.00	1350.00	1039.26	107.80	740.00	1400.00	1039.62	108.60	790.00	1370.00
Percent STEM Enrollment	0.15	0.10	0.00	0.82	0.12	0.09	0.00	0.68	0.12	0.09	0.00	0.73	0.13	0.09	0.00	0.84	0.14	0.09	0.00	0.85
Percent Women Enrollment	0.56	0.08	0.07	0.93	0.55	0.08	0.06	0.92	0.55	0.08	0.07	0.91	0.55	0.08	0.07	0.91	0.55	0.08	0.08	0.91
Percent URM Enrollment	0.24	0.24	0.02	0.98	0.24	0.24	0.02	0.98	0.25	0.23	0.01	0.97	0.25	0.23	0.03	0.96	0.26	0.23	0.03	0.96
HBCU	0.08	0.27	0.00	1.00	0.08	0.27	0.00	1.00	0.08	0.27	0.00	1.00	0.08	0.27	0.00	1.00	0.08	0.27	0.00	1.00
DOCTORAL	0.34	0.48	0.00	1.00	0.34	0.48	0.00	1.00	0.34	0.48	0.00	1.00	0.34	0.48	0.00	1.00	0.34	0.48	0.00	1.00
MASTERS	0.52	0.50	0.00	1.00	0.52	0.50	0.00	1.00	0.52	0.50	0.00	1.00	0.52	0.50	0.00	1.00	0.52	0.50	0.00	1.00
BACHELORS	0.13	0.34	0.00	1.00	0.13	0.34	0.00	1.00	0.13	0.34	0.00	1.00	0.13	0.34	0.00	1.00	0.13	0.34	0.00	1.00

Table 16

Descriptive Statistics for Independent Variables - Private Institutions

	2003				2004				2005				2006				2007			
	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
NSF Award Received (General)	0.01	0.10	0.00	1.00	0.02	0.14	0.00	1.00	0.03	0.16	0.00	1.00	0.03	0.16	0.00	1.00	0.01	0.10	0.00	1.00
NSF Award Received (Women)	0.00	0.06	0.00	1.00	0.01	0.08	0.00	1.00	0.01	0.08	0.00	1.00	0.01	0.11	0.00	1.00	0.01	0.08	0.00	1.00
NSF Award Received (URM)	0.01	0.08	0.00	1.00	0.01	0.11	0.00	1.00	0.00	0.05	0.00	1.00	0.01	0.12	0.00	1.00	0.01	0.10	0.00	1.00
Expenditures Instruction	8.00	10.42	-114.54	126.92	6.24	21.74	-527.47	44.53	6.83	15.55	-367.92	47.90	7.30	12.49	-257.56	51.15	7.54	13.21	-324.68	51.77
Expenditures Academic Support	1.97	3.23	-24.70	44.21	1.54	5.93	-139.64	39.76	1.73	4.06	-85.65	41.95	1.85	3.22	-49.03	42.26	1.91	3.43	-65.25	42.84
Expenditures Student Services	2.56	1.74	-15.90	26.85	2.43	3.21	-56.92	12.02	2.58	2.44	-39.00	12.57	2.73	2.33	-41.43	13.14	2.81	3.05	-70.55	13.42
Expenditures Institutional Support	3.94	4.09	-51.79	53.89	3.38	9.45	-182.76	43.62	3.64	6.78	-126.73	23.01	3.79	6.17	-131.61	20.66	3.82	8.13	-211.31	19.88
Expenditures Research	107.05	546.76	0.00	9809.69	113.46	558.39	0.00	9357.62	123.43	589.17	0.00	8695.97	130.88	616.26	0.00	8791.32	139.41	651.77	0.00	8712.75
Expenditures Public Services	24.26	68.76	0.00	819.52	25.46	72.01	0.00	944.43	31.30	106.63	0.00	1570.93	33.12	106.53	0.00	1190.34	32.81	100.00	0.00	1014.42
Size/Total Enrollment	23.02	24.04	0.07	299.32	23.46	24.51	0.08	306.17	23.74	24.82	0.06	307.98	23.97	25.13	0.09	304.80	24.19	25.54	0.10	308.73
Student to Faculty Ratio	12.69	6.76	0.10	116.85	12.61	6.76	0.15	139.78	12.41	6.53	0.00	136.31	12.18	6.73	0.17	150.35	11.91	6.08	0.12	132.59
SAT Average	1092.48	135.89	530.00	1520.00	1091.76	138.27	641.00	1510.00	1096.46	137.63	730.00	1510.00	1087.66	140.79	697.50	1520.00	1084.63	140.93	725.50	1525.00
Percent STEM Enrollment	0.10	0.10	0.00	0.78	0.10	0.10	0.00	0.78	0.10	0.10	0.00	1.00	0.11	0.09	0.00	0.80	0.12	0.10	0.00	0.83
Percent Women Enrollment	0.61	0.14	0.00	1.00	0.61	0.14	0.00	1.00	0.60	0.14	0.00	1.00	0.60	0.14	0.00	1.00	0.60	0.13	0.00	1.00
Percent URM Enrollment	0.18	0.22	0.00	1.00	0.19	0.22	0.00	1.00	0.19	0.22	0.00	1.00	0.19	0.21	0.00	1.00	0.19	0.21	0.00	1.00
WOMEN'S COLLEGE	0.05	0.22	0.00	1.00	0.05	0.22	0.00	1.00	0.05	0.22	0.00	1.00	0.05	0.22	0.00	1.00	0.05	0.22	0.00	1.00
HBCU	0.05	0.22	0.00	1.00	0.05	0.22	0.00	1.00	0.05	0.22	0.00	1.00	0.05	0.22	0.00	1.00	0.05	0.22	0.00	1.00
DOCTORAL	0.12	0.32	0.00	1.00	0.12	0.32	0.00	1.00	0.12	0.32	0.00	1.00	0.12	0.32	0.00	1.00	0.12	0.32	0.00	1.00
MASTERS	0.39	0.49	0.00	1.00	0.39	0.49	0.00	1.00	0.39	0.49	0.00	1.00	0.39	0.49	0.00	1.00	0.39	0.49	0.00	1.00
BACHELORS	0.49	0.50	0.00	1.00	0.49	0.50	0.00	1.00	0.49	0.50	0.00	1.00	0.49	0.50	0.00	1.00	0.49	0.50	0.00	1.00

Cont

	2008				2009				2010				2011				2012			
	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
NSF Award Received (General)	0.02	0.15	0.00	1.00	0.01	0.08	0.00	1.00	0.03	0.17	0.00	1.00	0.04	0.18	0.00	1.00	0.05	0.21	0.00	1.00
NSF Award Received (Women)	0.02	0.13	0.00	1.00	0.00	0.05	0.00	1.00	0.02	0.12	0.00	1.00	0.01	0.12	0.00	1.00	0.03	0.17	0.00	1.00
NSF Award Received (URM)	0.02	0.12	0.00	1.00	0.00	0.03	0.00	1.00	0.02	0.13	0.00	1.00	0.02	0.15	0.00	1.00	0.03	0.18	0.00	1.00
Expenditures Instruction	7.88	12.81	-301.47	54.55	8.22	12.68	-257.29	57.63	8.88	9.68	-181.95	61.12	9.19	11.72	-255.97	62.33	9.52	12.05	-251.29	79.32
Expenditures Academic Support	1.98	3.68	-59.47	46.09	2.08	4.15	-84.79	46.56	2.23	3.69	-64.87	49.39	2.33	4.34	-62.34	53.59	2.38	4.29	-63.18	54.28
Expenditures Student Services	2.98	3.07	-69.30	15.21	3.22	2.60	-49.47	17.21	3.42	2.58	-39.07	18.29	3.58	3.04	-57.19	19.78	3.74	3.05	-56.18	24.90
Expenditures Institutional Support	4.01	7.36	-175.52	23.86	4.27	7.20	-132.00	49.45	4.59	5.32	-106.68	34.95	4.85	5.55	-119.29	29.50	4.94	6.97	-154.95	26.24
Expenditures Research	147.16	689.63	0.00	9478.62	148.44	719.36	0.00	9962.55	153.78	746.83	0.00	10766.01	158.71	777.25	0.00	10824.94	166.36	832.80	0.00	12795.11
Expenditures Public Services	31.29	94.11	0.00	986.53	31.34	93.62	0.00	1044.45	33.32	119.06	0.00	2278.28	31.18	91.27	0.00	1070.65	31.49	95.01	0.00	1231.82
Size/Total Enrollment	24.46	25.98	0.11	309.12	24.89	26.97	0.07	307.45	25.43	28.18	0.15	351.21	25.65	28.98	0.17	394.84	25.73	30.25	0.22	457.81
Student to Faculty Ratio	11.68	5.81	0.19	125.87	11.64	4.21	0.10	48.67	11.61	4.28	0.17	50.29	11.43	4.26	0.21	52.67	11.31	4.48	0.30	78.67
SAT Average	1083.70	141.80	730.00	1515.00	1081.46	142.68	690.00	1515.00	1081.31	142.12	705.00	1525.00	1078.69	146.23	715.00	1525.00	1079.02	147.02	705.00	1525.00
Percent STEM Enrollment	0.13	0.10	0.00	0.81	0.10	0.09	0.00	0.78	0.11	0.09	0.01	0.79	0.11	0.09	0.00	0.81	0.12	0.10	0.00	0.82
Percent Women Enrollment	0.60	0.13	0.00	1.00	0.60	0.13	0.00	1.00	0.60	0.13	0.00	1.00	0.59	0.13	0.00	1.00	0.59	0.13	0.00	1.00
Percent URM Enrollment	0.20	0.21	0.00	1.00	0.21	0.21	0.01	1.00	0.21	0.21	0.01	1.00	0.22	0.21	0.00	1.00	0.22	0.21	0.01	1.00
WOMEN'S COLLEGE	0.05	0.22	0.00	1.00	0.05	0.22	0.00	1.00	0.05	0.22	0.00	1.00	0.05	0.22	0.00	1.00	0.05	0.22	0.00	1.00
HBCU	0.05	0.22	0.00	1.00	0.05	0.22	0.00	1.00	0.05	0.22	0.00	1.00	0.05	0.22	0.00	1.00	0.05	0.22	0.00	1.00
DOCTORAL	0.12	0.32	0.00	1.00	0.12	0.32	0.00	1.00	0.12	0.32	0.00	1.00	0.12	0.32	0.00	1.00	0.12	0.32	0.00	1.00
MASTERS	0.39	0.49	0.00	1.00	0.39	0.49	0.00	1.00	0.39	0.49	0.00	1.00	0.39	0.49	0.00	1.00	0.39	0.49	0.00	1.00
BACHELORS	0.49	0.50	0.00	1.00	0.49	0.50	0.00	1.00	0.49	0.50	0.00	1.00	0.49	0.50	0.00	1.00	0.49	0.50	0.00	1.00

Table 17

Random Effects Models for Total STEM Degree Production - Public

Variable	Model 1		Model 2		Model 3		Model 4	
	NSF Only		NSF & Time-Varying Variables		NSF, Time-Varying, Time-Invariant		NSF, Time-Varying, Time-Invariant, Year	
	β	Std. Err.	β	Std. Err.	β	Std. Err.	β	Std. Err.
NSF Award Received	**20.544500**	**3.582700**	*5.139700*	*3.198000*	*5.228800*	*3.195200*	*2.398500*	*3.146200*
Expenditures Instruction	.	.	**13.088100**	**1.416100**	**12.983900**	**1.419000**	**8.848000**	**1.455400**
Expenditures Academic Support	.	.	*-0.547900*	*1.908100*	*-0.761300*	*1.907800*	*-2.685000*	*1.877100*
Expenditures Student Services	.	.	**-15.525400**	**5.230100**	**-13.763400**	**5.279400**	**-27.223300**	**5.478800**
Expenditures Institutional Support	.	.	**-6.122700**	**2.695700**	**-5.869700**	**2.704200**	**-9.995800**	**2.692700**
Expenditures Research	.	.	**0.057470**	**0.008693**	**0.055540**	**0.008705**	**0.056670**	**0.008550**
Expenditures Public Services	.	.	**0.047990**	**0.024140**	*0.044100*	*0.024140*	*0.034130*	*0.023740*
Size/Total Enrollment	.	.	**3.045300**	**0.080250**	**2.987200**	**0.087330**	**2.902700**	**0.090180**
Student to Faculty Ratio	.	.	**-4.810700**	**0.755400**	**-4.554500**	**0.759600**	**-5.602900**	**0.760500**
SAT Average	.	.	**0.309900**	**0.037440**	**0.302300**	**0.037590**	**0.261500**	**0.037190**
Percent STEM Enrollment	.	.	**586.510000**	**50.094300**	**575.730000**	**50.222100**	**675.160000**	**57.725900**
Percent Women Enrollment	.	.	**-264.550000**	**66.938100**	**-243.590000**	**67.347600**	**-212.380000**	**68.214900**
Percent URM Enrollment	.	.	*10.290200*	*33.268600*	*-0.395400*	*40.651300*	*-79.219200*	*42.936100*
HBCU	.	.	.	.	*38.691600*	*48.885000*	*86.895000*	*49.998700*
DOCTORAL	.	.	.	.	*31.492100*	*36.333000*	*53.528100*	*37.298600*
MASTERS	.	.	.	.	*-49.131300*	*32.880800*	*-44.062600*	*33.361900*
Year 2003	.	.	.	.	.	.	**-35.558100**	**5.531700**
Year 2004	.	.	.	.	.	.	**-32.363100**	**5.511900**
Year 2005	.	.	.	.	.	.	**-35.697000**	**5.372300**
Year 2006	.	.	.	.	.	.	**-42.643100**	**5.212500**
Year 2007	.	.	.	.	.	.	**-48.490200**	**4.983300**
Year 2008	.	.	.	.	.	.	**-57.493900**	**4.727400**
Year 2009	.	.	.	.	.	.	**-36.365100**	**4.650000**
Year 2010	.	.	.	.	.	.	**-30.021900**	**4.325400**
Year 2011	.	.	.	.	.	.	**-17.866400**	**4.043000**
Intercept	**325.060000**	**19.528400**	**-225.550000**	**59.862800**	**-213.100000**	**64.530200**	*-84.051000*	*64.931200*

Table 18

Random Effects Models for Total STEM Degree Production - Private

Variable	Model 1		Model 2		Model 3		Model 4	
	NSF Only		NSF & Time-Varying Variables		NSF, Time-Varying, Time-Invariant		NSF, Time-Varying, Time-Invariant, Year	
	β	Std. Err.	β	Std. Err.	β	Std. Err.	β	Std. Err.
NSF Award Received	**10.804500**	**1.784500**	**10.279100**	**1.882500**	**10.257500**	**1.871700**	**8.876300**	**1.850100**
Expenditures Instruction	.	.	**0.712900**	**0.141500**	**0.574400**	**0.140900**	**0.514600**	**0.139700**
Expenditures Academic Support	.	.	**1.491900**	**0.380700**	**1.262300**	**0.377500**	**1.196100**	**0.372600**
Expenditures Student Services	.	.	*0.051590*	*0.425300*	*0.599100*	*0.426800*	*-0.542400*	*0.451100*
Expenditures Institutional Support	.	.	*-0.001800*	*0.251300*	*0.003157*	*0.249700*	*-0.220000*	*0.247400*
Expenditures Research	.	.	**0.034700**	**0.002040**	**0.030550**	**0.002033**	**0.028930**	**0.002033**
Expenditures Public Services	.	.	**0.029240**	**0.007227**	**0.027500**	**0.007171**	**0.030620**	**0.007082**
Size/Total Enrollment	.	.	**1.480600**	**0.068390**	**1.277400**	**0.070050**	**1.192300**	**0.070780**
Student to Faculty Ratio	.	.	*0.032140*	*0.113900*	*0.091770*	*0.113100*	*0.185400*	*0.113500*
SAT Average	.	.	**0.063540**	**0.008351**	**0.056110**	**0.008305**	**0.057420**	**0.008245**
Percent STEM Enrollment	.	.	**71.788600**	**9.367800**	**68.255800**	**9.300900**	**69.772100**	**9.587300**
Percent Women Enrollment	.	.	**-70.079200**	**11.613500**	**-61.980500**	**12.104000**	**-43.839000**	**12.178300**
Percent URM Enrollment	.	.	*11.583500*	*8.873500*	*13.072700*	*9.550600*	*-17.704000*	*10.180900*
HBCU	.	.	.	.	*-11.107500*	*17.377800*	*11.642200*	*17.777900*
WOMEN'S COLLEGE	.	.	.	.	*8.605200*	*14.320600*	*4.188500*	*14.485600*
DOCTORAL	.	.	.	.	**144.830000**	**10.572100**	**151.390000**	**10.732600**
MASTERS	.	.	.	.	*3.144900*	*6.755200*	*2.913800*	*6.840000*
Year 2003	.	.	.	.	.	.	**-7.903700**	**1.432400**
Year 2004	.	.	.	.	.	.	**-8.402500**	**1.409800**
Year 2005	.	.	.	.	.	.	**-11.720100**	**1.377400**
Year 2006	.	.	.	.	.	.	**-13.125000**	**1.331800**
Year 2007	.	.	.	.	.	.	**-12.502100**	**1.298800**
Year 2008	.	.	.	.	.	.	**-13.200800**	**1.262500**
Year 2009	.	.	.	.	.	.	**-10.200200**	**1.257000**
Year 2010	.	.	.	.	.	.	**-6.422400**	**1.224600**
Year 2011	.	.	.	.	.	.	**-3.981500**	**1.202700**
Intercept	**80.693800**	**4.834200**	*-6.464200*	*12.214500*	*-17.497500*	*12.485600*	*-10.449700*	*12.428700*

Table 19

Random Effects Models for STEM Degree Production Rate - Public

Variable	Model 1		Model 2		Model 3		Model 4	
	NSF Only		NSF & Time-Varying Variables		NSF, Time-Varying, Time-Invariant		NSF, Time-Varying, Time-Invariant, Year	
	β	Std. Err.	β	Std. Err.	β	Std. Err.	β	Std. Err.
NSF Award Received	*0.001782*	*0.001171*	*0.000623*	*0.001187*	*0.000703*	*0.001185*	*0.000462*	*0.001182*
Expenditures Instruction	.	.	**0.002305**	**0.000522**	**0.002274**	**0.000522**	**0.001912**	**0.000535**
Expenditures Academic Support	.	.	**0.001563**	**0.000707**	*0.001362*	*0.000706*	*0.000794*	*0.000701*
Expenditures Student Services	.	.	**-0.011000**	**0.001923**	**-0.009310**	**0.001938**	**-0.005780**	**0.002005**
Expenditures Institutional Support	.	.	*-0.001760*	*0.000997*	*-0.001700*	*0.000999*	*-0.001120*	*0.001000*
Expenditures Research	.	.	*0.000003*	*0.000003*	*0.000002*	*0.000003*	*0.000004*	*0.000003*
Expenditures Public Services	.	.	*0.000013*	*0.000009*	*0.000010*	*0.000009*	*0.000012*	*0.000009*
Size/Total Enrollment	.	.	**-0.000090**	**0.000029**	**-0.000120**	**0.000031**	*-0.000050*	*0.000030*
Student to Faculty Ratio	.	.	*0.000517*	*0.000279*	**0.000706**	**0.000280**	*-0.000220*	*0.000280*
SAT Average	.	.	*0.000006*	*0.000014*	*0.000001*	*0.000014*	*0.000001*	*0.000014*
Percent STEM Enrollment	.	.	**0.229300**	**0.018330**	**0.228800**	**0.018300**	**0.389800**	**0.020240**
Percent Women Enrollment	.	.	**-0.166800**	**0.024230**	**-0.165300**	**0.024180**	**-0.230700**	**0.023420**
Percent URM Enrollment	.	.	*-0.014150*	*0.011630*	**-0.041900**	**0.014300**	*-0.004220*	*0.013880*
HBCU	.	.	.	.	**0.062190**	**0.016260**	**0.040120**	**0.014360**
DOCTORAL	.	.	.	.	**0.037090**	**0.011900**	*0.012230*	*0.010340*
MASTERS	.	.	.	.	*-0.004640*	*0.010640*	*-0.006940*	*0.008932*
Year 2003	.	.	.	.	.	.	**0.015310**	**0.001999**
Year 2004	.	.	.	.	.	.	**0.011920**	**0.001999**
Year 2005	.	.	.	.	.	.	**0.008439**	**0.001962**
Year 2006	.	.	.	.	.	.	*0.002764*	*0.001915*
Year 2007	.	.	.	.	.	.	*-0.003250*	*0.001840*
Year 2008	.	.	.	.	.	.	**-0.008780**	**0.001755**
Year 2009	.	.	.	.	.	.	*0.003007*	*0.001719*
Year 2010	.	.	.	.	.	.	*0.001693*	*0.001611*
Year 2011	.	.	.	.	.	.	*0.000790*	*0.001516*
Intercept	**0.147300**	**0.004259**	**0.207100**	**0.021830**	**0.201000**	**0.022960**	*0.222200*	*0.022060*

Table 20

Random Effects Models for STEM Degree Production Rate - Private

Variable	Model 1		Model 2		Model 3		Model 4	
	NSF Only		NSF & Time-Varying Variables		NSF, Time-Varying, Time-Invariant		NSF, Time-Varying, Time-Invariant, Year	
	β	Std. Err.	β	Std. Err.	β	Std. Err.	β	Std. Err.
NSF Award Received	**0.004829**	**0.002298**	*0.003617*	*0.002284*	*0.003597*	*0.002280*	*0.002810*	*0.002258*
Expenditures Instruction	.	.	**0.000746**	**0.000170**	**0.000653**	**0.000171**	**0.000544**	**0.000169**
Expenditures Academic Support	.	.	*0.000055*	*0.000455*	*-0.000150*	*0.000453*	*-0.000190*	*0.000447*
Expenditures Student Services	.	.	*0.000690*	*0.000509*	**0.001288**	**0.000515**	**0.002074**	**0.000545**
Expenditures Institutional Support	.	.	*-0.000400*	*0.000303*	*-0.000450*	*0.000303*	*-0.000400*	*0.000300*
Expenditures Research	.	.	**0.000020**	**0.000002**	**0.000018**	**0.000002**	*0.000020*	*0.000002*
Expenditures Public Services	.	.	*-0.000003*	*0.000009*	*-0.000006*	*0.000009*	**-0.000001**	**0.000009**
Size/Total Enrollment	.	.	**-0.000380**	**0.000077**	**-0.000510**	**0.000081**	**-0.000400**	**0.000081**
Student to Faculty Ratio	.	.	*-0.000030*	*0.000137*	*0.000009*	*0.000137*	*-0.000180*	*0.000137*
SAT Average	.	.	**0.000070**	**0.000010**	**0.000065**	**0.000010**	**0.000059**	**0.000010**
Percent STEM Enrollment	.	.	**0.121900**	**0.011180**	**0.119100**	**0.011160**	**0.145800**	**0.011470**
Percent Women Enrollment	.	.	**-0.141400**	**0.013260**	**-0.147700**	**0.014240**	**-0.158300**	**0.014220**
Percent URM Enrollment	.	.	*0.001368*	*0.010060*	**-0.025270**	**0.011300**	*-0.013640*	*0.011950*
HBCU	.	.	.	.	**0.086050**	**0.017800**	**0.074650**	**0.017700**
WOMEN'S COLLEGE	.	.	.	.	**0.042080**	**0.014410**	**0.045930**	**0.014050**
DOCTORAL	.	.	.	.	**0.075250**	**0.010700**	**0.066170**	**0.010500**
MASTERS	.	.	.	.	*-0.012770*	*0.006690*	**-0.013170**	**0.006512**
Year 2003	.	.	.	.	.	.	**0.006038**	**0.001734**
Year 2004	.	.	.	.	.	.	**0.003850**	**0.001708**
Year 2005	.	.	.	.	.	.	*-0.000270*	*0.001671*
Year 2006	.	.	.	.	.	.	**-0.004740**	**0.001617**
Year 2007	.	.	.	.	.	.	**-0.007030**	**0.001579**
Year 2008	.	.	.	.	.	.	**-0.011290**	**0.001537**
Year 2009	.	.	.	.	.	.	**-0.007910**	**0.001531**
Year 2010	.	.	.	.	.	.	**-0.003610**	**0.001493**
Year 2011	.	.	.	.	.	.	*-0.002620*	*0.001468*
Intercept	**0.128200**	**0.003872**	**0.125600**	**0.014210**	**0.132900**	**0.014580**	**0.142600**	**0.014430**

Table 21

Random Effects Models for Women STEM Degree Production - Public

Variable	Model 1		Model 2		Model 3		Model 4	
	NSF Only		NSF & Time-Varying Variables		NSF, Time-Varying, Time-Invariant		NSF, Time-Varying, Time-Invariant, Year	
	β	Std. Err.	β	Std. Err.	β	Std. Err.	β	Std. Err.
NSF Award Received	**6.539700**	**1.990100**	*1.062100*	*1.908200*	*1.093300*	*1.907700*	*0.416400*	*1.887100*
Expenditures Instruction	.	.	**4.592900**	**0.595300**	**4.584300**	**0.597100**	**3.198700**	**0.617800**
Expenditures Academic Support	.	.	*-0.157200*	*0.806300*	*-0.235000*	*0.806800*	*-0.890700*	*0.800800*
Expenditures Student Services	.	.	**-6.826200**	**2.190900**	**-6.209200**	**2.216000**	**-10.303000**	**2.322300**
Expenditures Institutional Support	.	.	*-1.677000*	*1.136700*	*-1.652000*	*1.141300*	**-2.909200**	**1.145900**
Expenditures Research	.	.	**0.019550**	**0.003661**	**0.018920**	**0.003670**	**0.019270**	**0.003637**
Expenditures Public Services	.	.	**0.022090**	**0.010110**	**0.020720**	**0.010110**	*0.018330*	*0.010040*
Size/Total Enrollment	.	.	**1.003000**	**0.032320**	**0.990700**	**0.035570**	**0.968300**	**0.036970**
Student to Faculty Ratio	.	.	**-1.497100**	**0.317800**	**-1.414100**	**0.320100**	**-1.802200**	**0.323000**
SAT Average	.	.	**0.116800**	**0.015720**	**0.114900**	**0.015800**	**0.101800**	**0.015770**
Percent STEM Enrollment	.	.	**213.110000**	**20.877300**	**210.160000**	**20.948200**	**248.790000**	**24.095500**
Percent Women Enrollment	.	.	*-40.830700*	*27.495200*	*-34.549200*	*27.677800*	*-27.826500*	*28.257500*
Percent URM Enrollment	.	.	*17.530900*	*13.084300*	*8.790400*	*16.371200*	*-13.373300*	*17.384300*
HBCU	.	.	.	.	*20.203000*	*18.649200*	*33.653500*	*19.192700*
DOCTORAL	.	.	.	.	*5.610900*	*13.651700*	*11.302300*	*14.094800*
MASTERS	.	.	.	.	*-15.523600*	*12.206500*	*-14.155700*	*12.436200*
Year 2003	.	.	.	.	.	.	**-10.075000**	**2.330100**
Year 2004	.	.	.	.	.	.	**-9.532900**	**2.324600**
Year 2005	.	.	.	.	.	.	**-11.379700**	**2.273900**
Year 2006	.	.	.	.	.	.	**-12.533600**	**2.209000**
Year 2007	.	.	.	.	.	.	**-15.488700**	**2.113900**
Year 2008	.	.	.	.	.	.	**-18.519800**	**2.010800**
Year 2009	.	.	.	.	.	.	**-11.098200**	**1.970400**
Year 2010	.	.	.	.	.	.	**-9.164700**	**1.842600**
Year 2011	.	.	.	.	.	.	**-4.982400**	**1.727100**
Intercept	**113.010000**	**6.618600**	**-117.700000**	**24.821000**	**-112.630000**	**26.278600**	**-70.412400**	**26.639100**

Table 22

Random Effects Models for Women STEM Degree Production - Private

Variable	Model 1		Model 2		Model 3		Model 4	
	NSF Only		NSF & Time-Varying Variables		NSF, Time-Varying, Time-Invariant		NSF, Time-Varying, Time-Invariant, Year	
	β	Std. Err.	β	Std. Err.	β	Std. Err.	β	Std. Err.
NSF Award Received	*1.817300*	*1.235500*	*0.709200*	*1.297000*	*0.750500*	*1.291600*	*-0.273700*	*1.273700*
Expenditures Instruction	.	.	**0.341300**	**0.067430**	**0.281500**	**0.067430**	**0.266400**	**0.066790**
Expenditures Academic Support	.	.	**0.617100**	**0.176500**	**0.515000**	**0.175500**	**0.498000**	**0.173300**
Expenditures Student Services	.	.	*0.059910*	*0.198600*	*0.304300*	*0.201900*	*-0.428800*	*0.213900*
Expenditures Institutional Support	.	.	*-0.002550*	*0.120700*	*-0.020890*	*0.120200*	*-0.149500*	*0.118900*
Expenditures Research	.	.	*0.019840*	*0.000862*	**0.018040**	**0.000874**	**0.017380**	**0.000872**
Expenditures Public Services	.	.	*0.012260*	*0.003411*	**0.011010**	**0.003393**	**0.012440**	**0.003348**
Size/Total Enrollment	.	.	**0.724300**	**0.026540**	**0.650200**	**0.028620**	**0.608200**	**0.028930**
Student to Faculty Ratio	.	.	*-0.096260*	*0.054040*	*-0.062910*	*0.053890*	*0.002433*	*0.053970*
SAT Average	.	.	**0.035680**	**0.003790**	**0.032280**	**0.003793**	**0.034040**	**0.003776**
Percent STEM Enrollment	.	.	**43.949100**	**4.330300**	**40.544600**	**4.323900**	**40.406600**	**4.432900**
Percent Women Enrollment	.	.	*-8.822800*	*4.682600*	**-12.376400**	**5.272200**	*-4.641200*	*5.282700*
Percent URM Enrollment	.	.	**10.358000**	**3.510200**	*7.345400*	*4.233000*	*-8.487400*	*4.463300*
HBCU	.	.	.	.	*4.313100*	*5.547500*	**16.202100**	**5.684500**
WOMEN'S COLLEGE	.	.	.	.	**15.314900**	**4.340300**	**13.744600**	**4.358600**
DOCTORAL	.	.	.	.	**27.205000**	**3.248800**	**29.984000**	**3.280400**
MASTERS	.	.	.	.	*-2.355200*	*1.955200*	*-2.565800*	*1.966500*
Year 2003	.	.	.	.	.	.	**-5.484600**	**0.685500**
Year 2004	.	.	.	.	.	.	**-5.244200**	**0.676300**
Year 2005	.	.	.	.	.	.	**-6.917200**	**0.663400**
Year 2006	.	.	.	.	.	.	**-6.852000**	**0.642400**
Year 2007	.	.	.	.	.	.	**-7.063100**	**0.628100**
Year 2008	.	.	.	.	.	.	**-7.437600**	**0.612800**
Year 2009	.	.	.	.	.	.	**-5.637900**	**0.611200**
Year 2010	.	.	.	.	.	.	**-3.741300**	**0.597200**
Year 2011	.	.	.	.	.	.	**-2.633300**	**0.588000**
Intercept	**33.931600**	**1.603200**	**-29.835800**	**5.290800**	**-24.765000**	**5.464000**	**-20.513800**	**5.432300**

Table 23

Random Effects Models for Women STEM Degree Production Rate - Public

Variable	Model 1		Model 2		Model 3		Model 4	
	NSF Only		NSF & Time-Varying Variables		NSF, Time-Varying, Time-Invariant		NSF, Time-Varying, Time-Invariant, Year	
	β	Std. Err.	β	Std. Err.	β	Std. Err.	β	Std. Err.
NSF Award Received	*0.000238*	*0.001670*	*-0.001510*	*0.001707*	*-0.001400*	*0.001702*	*-0.000850*	*0.001703*
Expenditures Instruction	.	.	**0.001671**	**0.000516**	**0.001755**	**0.000516**	**0.001702**	**0.000528**
Expenditures Academic Support	.	.	*0.000895*	*0.000715*	*0.000712*	*0.000714*	*0.000308*	*0.000712*
Expenditures Student Services	.	.	**-0.009770**	**0.001874**	**-0.008530**	**0.001896**	**-0.004180**	**0.001956**
Expenditures Institutional Support	.	.	*-0.000460*	*0.000999*	*-0.000660*	*0.001001*	*0.000063*	*0.001003*
Expenditures Research	.	.	*0.000004*	*0.000003*	*0.000003*	*0.000003*	*0.000004*	*0.000003*
Expenditures Public Services	.	.	*0.000009*	*0.000009*	*0.000006*	*0.000009*	*0.000006*	*0.000008*
Size/Total Enrollment	.	.	**-0.000160**	**0.000024**	**-0.000160**	**0.000027**	**-0.000110**	**0.000026**
Student to Faculty Ratio	.	.	*0.000345*	*0.000275*	*0.000475*	*0.000277*	*-0.000190*	*0.000276*
SAT Average	.	.	**0.000039**	**0.000014**	**0.000037**	**0.000014**	**0.000035**	**0.000013**
Percent STEM Enrollment	.	.	**0.278000**	**0.017430**	**0.276900**	**0.017430**	**0.405900**	**0.018640**
Percent Women Enrollment	.	.	**-0.185700**	**0.021830**	**-0.179200**	**0.021890**	**-0.198500**	**0.020910**
Percent URM Enrollment	.	.	**0.030570**	**0.009239**	*-0.005880*	*0.012130*	*0.021420*	*0.011500*
HBCU	.	.	.	.	**0.057720**	**0.012250**	**0.038900**	**0.010930**
DOCTORAL	.	.	.	.	*0.006117*	*0.008705*	*-0.010640*	*0.007708*
MASTERS	.	.	.	.	*-0.009340*	*0.007484*	*-0.010770*	*0.006417*
Year 2003	.	.	.	.	.	.	**0.015600**	**0.001951**
Year 2004	.	.	.	.	.	.	**0.012430**	**0.001959**
Year 2005	.	.	.	.	.	.	**0.009341**	**0.001943**
Year 2006	.	.	.	.	.	.	**0.006111**	**0.001908**
Year 2007	.	.	.	.	.	.	*0.000803*	*0.001842*
Year 2008	.	.	.	.	.	.	**-0.004800**	**0.001772**
Year 2009	.	.	.	.	.	.	**0.007019**	**0.001724**
Year 2010	.	.	.	.	.	.	**0.005596**	**0.001636**
Year 2011	.	.	.	.	.	.	*0.002961*	*0.001555*
Intercept	**0.097260**	**0.003456**	**0.128500**	**0.020530**	**0.130000**	**0.020950**	**0.123400**	**0.020260**

Table 24

Random Effects Models for Women STEM Degree Production Rate - Private

Variable	Model 1		Model 2		Model 3		Model 4	
	NSF Only		NSF & Time-Varying Variables		NSF, Time-Varying, Time-Invariant		NSF, Time-Varying, Time-Invariant, Year	
	β	Std. Err.	β	Std. Err.	β	Std. Err.	β	Std. Err.
NSF Award Received	*0.000471*	*0.003391*	*0.000245*	*0.003397*	*0.000245*	*0.003394*	*-0.000250*	*0.003374*
Expenditures Instruction	.	.	**0.000690**	**0.000178**	**0.000617**	**0.000179**	**0.000524**	**0.000178**
Expenditures Academic Support	.	.	*-0.000250*	*0.000472*	*-0.000430*	*0.000470*	*-0.000460*	*0.000465*
Expenditures Student Services	.	.	**0.001117**	**0.000531**	**0.001612**	**0.000539**	**0.001650**	**0.000573**
Expenditures Institutional Support	.	.	*-0.000230*	*0.000319*	*-0.000310*	*0.000318*	*-0.000380*	*0.000317*
Expenditures Research	.	.	**0.000022**	**0.000002**	**0.000020**	**0.000002**	**0.000020**	**0.000002**
Expenditures Public Services	.	.	*-0.000020*	*0.000009*	**-0.000020**	**0.000009**	*-0.000020*	*0.000009*
Size/Total Enrollment	.	.	**-0.000430**	**0.000075**	**-0.000500**	**0.000079**	**-0.000460**	**0.000080**
Student to Faculty Ratio	.	.	*-0.000130*	*0.000143*	*-0.000100*	*0.000143*	*-0.000190*	*0.000144*
SAT Average	.	.	**0.000061**	**0.000010**	**0.000057**	**0.000010**	**0.000054**	**0.000010**
Percent STEM Enrollment	.	.	**0.169500**	**0.012240**	**0.168000**	**0.012200**	**0.194700**	**0.012640**
Percent Women Enrollment	.	.	**-0.136400**	**0.013420**	**-0.162100**	**0.014760**	**-0.161800**	**0.014790**
Percent URM Enrollment	.	.	*0.018530*	*0.009949*	*-0.015380*	*0.011490*	*-0.018560*	*0.012140*
HBCU	.	.	.	.	**0.088160**	**0.016230**	**0.088110**	**0.016270**
WOMEN'S COLLEGE	.	.	.	.	**0.069750**	**0.012780**	**0.070620**	**0.012540**
DOCTORAL	.	.	.	.	**0.044710**	**0.009527**	**0.040260**	**0.009408**
MASTERS	.	.	.	.	**-0.015290**	**0.005814**	**-0.015680**	**0.005691**
Year 2003	.	.	.	.	.	.	*0.001023*	*0.001832*
Year 2004	.	.	.	.	.	.	*-0.001130*	*0.001807*
Year 2005	.	.	.	.	.	.	**-0.004700**	**0.001770**
Year 2006	.	.	.	.	.	.	**-0.007400**	**0.001712**
Year 2007	.	.	.	.	.	.	**-0.008890**	**0.001672**
Year 2008	.	.	.	.	.	.	**-0.014440**	**0.001630**
Year 2009	.	.	.	.	.	.	**-0.008130**	**0.001628**
Year 2010	.	.	.	.	.	.	**-0.004100**	**0.001589**
Year 2011	.	.	.	.	.	.	**-0.003820**	**0.001563**
Intercept	**0.104900**	**0.003528**	**0.102700**	**0.014520**	**0.123300**	**0.014930**	**0.131000**	**0.014830**

Table 25

Random Effects Models for URM STEM Degree Production - Public

Variable	Model 1		Model 2		Model 3		Model 4	
	NSF Only		NSF & Time-Varying Variables		NSF, Time-Varying, Time-Invariant		NSF, Time-Varying, Time-Invariant, Year	
	β	Std. Err.	β	Std. Err.	β	Std. Err.	β	Std. Err.
NSF Award Received	**5.525500**	**1.087600**	**2.943600**	**1.005900**	**2.894600**	**1.006000**	**2.489700**	**1.002900**
Expenditures Instruction	.	.	*0.342500*	*0.359000*	*0.327300*	*0.360000*	*-0.245100*	*0.373200*
Expenditures Academic Support	.	.	*0.709100*	*0.492400*	*0.776100*	*0.492800*	*0.363300*	*0.491000*
Expenditures Student Services	.	.	*-2.547100*	*1.310400*	**-3.273900**	**1.326600**	**-4.263900**	**1.395900**
Expenditures Institutional Support	.	.	**-1.858600**	**0.690700**	**-1.834400**	**0.693700**	**-2.217400**	**0.698700**
Expenditures Research	.	.	**0.006932**	**0.002215**	**0.007147**	**0.002221**	**0.007847**	**0.002209**
Expenditures Public Services	.	.	*0.005273*	*0.006026*	*0.005408*	*0.006023*	*0.004948*	*0.005989*
Size/Total Enrollment	.	.	**0.498600**	**0.017870**	**0.502600**	**0.019890**	**0.512600**	**0.020460**
Student to Faculty Ratio	.	.	*-0.035730*	*0.191400*	*-0.081830*	*0.192900*	*-0.357500*	*0.194900*
SAT Average	.	.	**0.042940**	**0.009441**	**0.044930**	**0.009490**	**0.040270**	**0.009494**
Percent STEM Enrollment	.	.	**78.051300**	**12.306400**	**79.091200**	**12.324600**	**102.990000**	**13.943900**
Percent Women Enrollment	.	.	*-25.244500*	*15.746000*	*-23.383100*	*15.779900*	*-27.278100*	*16.046600*
Percent URM Enrollment	.	.	**153.300000**	**6.955200**	**169.620000**	**8.958800**	**167.690000**	**9.376700**
HBCU	.	.	.	.	**-25.981400**	**9.382100**	**-24.354400**	**9.513800**
DOCTORAL	.	.	.	.	**-19.521500**	**6.718800**	**-21.073600**	**6.815600**
MASTERS	.	.	.	.	**-17.822800**	**5.858000**	**-18.066100**	**5.842900**
Year 2003	.	.	.	.	.	.	*-2.376600*	*1.388600*
Year 2004	.	.	.	.	.	.	**-2.852200**	**1.390100**
Year 2005	.	.	.	.	.	.	**-4.287700**	**1.368900**
Year 2006	.	.	.	.	.	.	**-5.949900**	**1.336100**
Year 2007	.	.	.	.	.	.	**-8.086900**	**1.284800**
Year 2008	.	.	.	.	.	.	**-8.542700**	**1.227000**
Year 2009	.	.	.	.	.	.	**-5.580200**	**1.199800**
Year 2010	.	.	.	.	.	.	**-5.529500**	**1.127000**
Year 2011	.	.	.	.	.	.	**-3.550600**	**1.063000**
Intercept	**43.742100**	**2.837300**	**-82.408300**	**14.547000**	**-70.165300**	**14.986900**	**-51.153900**	**15.157100**

Table 26

Random Effects Models for URM STEM Degree Production - Private

Variable	Model 1		Model 2		Model 3		Model 4	
	NSF Only		NSF & Time-Varying Variables		NSF, Time-Varying, Time-Invariant		NSF, Time-Varying, Time-Invariant, Year	
	β	Std. Err.	β	Std. Err.	β	Std. Err.	β	Std. Err.
NSF Award Received	*-0.057910*	*0.562500*	*-0.274100*	*0.595900*	*-0.269100*	*0.593100*	*-0.401100*	*0.593000*
Expenditures Instruction	.	.	**0.198500**	**0.033560**	**0.178700**	**0.033510**	**0.166600**	**0.033580**
Expenditures Academic Support	.	.	*0.071680*	*0.088700*	*0.022890*	*0.088020*	*0.020010*	*0.087750*
Expenditures Student Services	.	.	**-0.226200**	**0.099410**	*-0.026580*	*0.100700*	*0.013130*	*0.107800*
Expenditures Institutional Support	.	.	**-0.232600**	**0.059950**	**-0.240000**	**0.059640**	**-0.242600**	**0.059700**
Expenditures Research	.	.	**0.004739**	**0.000445**	**0.004096**	**0.000448**	**0.004248**	**0.000450**
Expenditures Public Services	.	.	**0.009276**	**0.001705**	**0.008649**	**0.001693**	**0.009200**	**0.001689**
Size/Total Enrollment	.	.	**0.216200**	**0.014030**	**0.188200**	**0.014860**	**0.195900**	**0.015070**
Student to Faculty Ratio	.	.	*0.046560*	*0.026950*	*0.051660*	*0.026820*	*0.038340*	*0.027170*
SAT Average	.	.	**0.010400**	**0.001916**	**0.009606**	**0.001911**	**0.009053**	**0.001918**
Percent STEM Enrollment	.	.	**11.291200**	**2.177800**	**9.373900**	**2.167900**	**10.812800**	**2.247200**
Percent Women Enrollment	.	.	**-4.932800**	**2.451300**	*-3.748300*	*2.692300*	*-4.051300*	*2.716800*
Percent URM Enrollment	.	.	**30.838300**	**1.846500**	**20.799500**	**2.152400**	**20.967900**	**2.291600**
HBCU	.	.	.	.	**26.848500**	**2.998100**	**26.519800**	**3.053700**
WOMEN'S COLLEGE	.	.	.	.	*1.608500*	*2.376200*	*1.756400*	*2.368800*
DOCTORAL	.	.	.	.	**13.613300**	**1.774700**	**13.075900**	**1.779500**
MASTERS	.	.	.	.	*1.444000*	*1.083300*	*1.373300*	*1.078900*
Year 2003	.	.	.	.	.	.	*0.034360*	*0.344300*
Year 2004	.	.	.	.	.	.	*-0.153500*	*0.339500*
Year 2005	.	.	.	.	.	.	*-0.618800*	*0.333000*
Year 2006	.	.	.	.	.	.	**-1.188000**	**0.322100**
Year 2007	.	.	.	.	.	.	**-1.109900**	**0.314800**
Year 2008	.	.	.	.	.	.	**-1.539800**	**0.307000**
Year 2009	.	.	.	.	.	.	**-1.292400**	**0.306000**
Year 2010	.	.	.	.	.	.	**-0.948900**	**0.298800**
Year 2011	.	.	.	.	.	.	**-0.821400**	**0.293900**
Intercept	**9.492200**	**0.690200**	**-12.695100**	**2.703400**	**-13.494900**	**2.770900**	**-12.111400**	**2.775400**

Table 27

Random Effects Models for URM STEM Degree Production Rate - Public

Variable	Model 1		Model 2		Model 3		Model 4	
	NSF Only		NSF & Time-Varying Variables		NSF, Time-Varying, Time-Invariant		NSF, Time-Varying, Time-Invariant, Year	
	β	Std. Err.	β	Std. Err.	β	Std. Err.	β	Std. Err.
NSF Award Received	*0.000207*	*0.002978*	*-0.002330*	*0.002880*	*-0.002160*	*0.002873*	*-0.001310*	*0.002865*
Expenditures Instruction	.	.	*0.000988*	*0.000915*	*0.001047*	*0.000920*	*0.001722*	*0.000942*
Expenditures Academic Support	.	.	*0.000832*	*0.001361*	*0.000511*	*0.001361*	*-0.000200*	*0.001351*
Expenditures Student Services	.	.	**-0.008280**	**0.003238**	**-0.006530**	**0.003290**	*0.001221*	*0.003404*
Expenditures Institutional Support	.	.	*-0.002880*	*0.001850*	*-0.003170*	*0.001860*	*-0.001480*	*0.001860*
Expenditures Research	.	.	**0.000013**	**0.000006**	*0.000011*	*0.000006*	*0.000009*	*0.000006*
Expenditures Public Services	.	.	*-0.000020*	*0.000014*	*-0.000020*	*0.000014*	*-0.000020*	*0.000014*
Size/Total Enrollment	.	.	**-0.000190**	**0.000033**	**-0.000200**	**0.000038**	**-0.000130**	**0.000038**
Student to Faculty Ratio	.	.	*0.000128*	*0.000491*	*0.000340*	*0.000497*	*-0.000170*	*0.000498*
SAT Average	.	.	*0.000031*	*0.000024*	*0.000027*	*0.000024*	*0.000010*	*0.000024*
Percent STEM Enrollment	.	.	**0.396700**	**0.028530**	**0.393200**	**0.028670**	**0.486900**	**0.030220**
Percent Women Enrollment	.	.	**-0.389400**	**0.032340**	**-0.375500**	**0.032730**	**-0.379400**	**0.032340**
Percent URM Enrollment	.	.	**0.060120**	**0.012130**	*0.016430*	*0.016590*	**0.039550**	**0.016460**
HBCU	.	.	.	.	**0.055250**	**0.014940**	**0.036110**	**0.014590**
DOCTORAL	.	.	.	.	*0.015650*	*0.010510*	**0.001158**	**0.010200**
MASTERS	.	.	.	.	*0.002048*	*0.008568*	**0.001199**	**0.008220**
Year 2003	.	.	.	.	.	.	**0.024400**	**0.003583**
Year 2004	.	.	.	.	.	.	**0.025450**	**0.003615**
Year 2005	.	.	.	.	.	.	**0.014520**	**0.003628**
Year 2006	.	.	.	.	.	.	**0.013180**	**0.003586**
Year 2007	.	.	.	.	.	.	*0.002074*	*0.003485*
Year 2008	.	.	.	.	.	.	*-0.000320*	*0.003378*
Year 2009	.	.	.	.	.	.	**0.010920**	**0.003288**
Year 2010	.	.	.	.	.	.	**0.006656**	**0.003152**
Year 2011	.	.	.	.	.	.	*0.003730*	*0.003035*
Intercept	**0.122000**	**0.004009**	**0.266600**	**0.033380**	**0.259500**	**0.033630**	**0.244300**	**0.033470**

Table 28

Random Effects Models for URM STEM Degree Production Rate - Private

Variable	Model 1		Model 2		Model 3		Model 4	
	NSF Only		NSF & Time-Varying Variables		NSF, Time-Varying, Time-Invariant		NSF, Time-Varying, Time-Invariant, Year	
	β	Std. Err.	β	Std. Err.	β	Std. Err.	β	Std. Err.
NSF Award Received	*0.005112*	*0.007291*	*0.004839*	*0.007534*	*0.004247*	*0.007515*	*0.005247*	*0.007511*
Expenditures Instruction	.	.	*0.000491*	*0.000381*	*0.000365*	*0.000381*	*0.000236*	*0.000381*
Expenditures Academic Support	.	.	*0.000250*	*0.000873*	*-0.000060*	*0.000869*	*-0.000080*	*0.000860*
Expenditures Student Services	.	.	**-0.003260**	**0.001063**	**-0.002390**	**0.001092**	*-0.000520*	*0.001155*
Expenditures Institutional Support	.	.	*0.000496*	*0.000689*	*0.000209*	*0.000689*	*0.000376*	*0.000686*
Expenditures Research	.	.	**0.000021**	**0.000004**	**0.000019**	**0.000004**	**0.000020**	**0.000004**
Expenditures Public Services	.	.	**0.000059**	**0.000018**	**0.000049**	**0.000018**	**0.000052**	**0.000018**
Size/Total Enrollment	.	.	**-0.000400**	**0.000095**	**-0.000520**	**0.000108**	**-0.000410**	**0.000107**
Student to Faculty Ratio	.	.	*0.000194*	*0.000293*	*0.000317*	*0.000295*	*0.000028*	*0.000296*
SAT Average	.	.	**0.000091**	**0.000018**	**0.000082**	**0.000018**	**0.000065**	**0.000019**
Percent STEM Enrollment	.	.	**0.432900**	**0.021380**	**0.406300**	**0.021610**	**0.444600**	**0.021880**
Percent Women Enrollment	.	.	**-0.116100**	**0.017510**	**-0.181300**	**0.022400**	**-0.182400**	**0.022140**
Percent URM Enrollment	.	.	**0.041570**	**0.012990**	*-0.015910*	*0.018340*	*0.000764*	*0.018550*
HBCU	.	.	.	.	**0.079710**	**0.018740**	**0.062210**	**0.018760**
WOMEN'S COLLEGE	.	.	.	.	**0.074060**	**0.013570**	**0.073320**	**0.013320**
DOCTORAL	.	.	.	.	**0.035640**	**0.010140**	**0.029020**	**0.009982**
MASTERS	.	.	.	.	*0.003415*	*0.005643*	*0.003613*	*0.005533*
Year 2003	.	.	.	.	.	.	**0.019010**	**0.004119**
Year 2004	.	.	.	.	.	.	**0.020870**	**0.004086**
Year 2005	.	.	.	.	.	.	**0.010910**	**0.004048**
Year 2006	.	.	.	.	.	.	*0.001593*	*0.003944*
Year 2007	.	.	.	.	.	.	*-0.000570*	*0.003889*
Year 2008	.	.	.	.	.	.	*-0.006810*	*0.003829*
Year 2009	.	.	.	.	.	.	*0.002788*	*0.003839*
Year 2010	.	.	.	.	.	.	*0.002959*	*0.003779*
Year 2011	.	.	.	.	.	.	**0.008073**	**0.003742**
Intercept	**0.104400**	**0.003575**	*0.028270*	*0.023910*	**0.079390**	**0.025520**	**0.082050**	**0.025380**

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